TEACHERS’ KNOWLEDGE OF CLASSROOM ACOUSTICS;

A PILOT STUDY

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Megan Dempster

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"You have brains in your head. You have feet in your shoes. You can steer yourself any direction you choose. You're on your own. And you know what you know. And YOU are the one who'll decide where to go…."

- Oh, the places you'll go! By Dr Seuss

ABSTRACT

Purpose: This pilot study explored the knowledge held by NZ primary school teachers regarding classroom acoustics, and investigated the effectiveness of an information package for improving teachers' knowledge of classroom acoustics.

Methods: Twenty teachers (10 = MLEs and 10 = traditional), all whom had never heard of the Ministry of Education (MoE) acoustic guidelines, participated in this study. Participants completed an online survey which investigated their knowledge regarding different aspects of classroom acoustics. After the completion of the initial survey, participants were sent a portable document format (PDF) information package. Following this, a post-survey was distributed to all participants. Results were analysed using Microsoft Excel 2010 and the Statistical Package for Social Sciences (IBM, 2016).

Results: A significant difference existed in ability to elaborate upon 'reverberation' between the two survey conditions for teachers of MLE classrooms. A significant change was witnessed between the pre and post surveys regarding the importance of reducing external noise. Whilst qualitative improvements were observed across the majority of questions, the information package and classroom type had no significant effect on how teachers' rated their classroom listening environments, which proportion of noise inside the classroom was student generated or whether issues were reported regarding external noise.

Conclusion: Teachers' knowledge of classroom acoustics was not significantly influenced by the type of classroom environment. Qualitative improvements in knowledge were observed following the distribution of the information package, though rarely at a level indicative of statistical significance. Further research regarding the effectiveness of an information package may lead to the development of a training programme to support teachers' knowledge regarding classroom acoustics.

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ABBREVIATIONS

10YPP	Ten Tear Property Plan
AL	Activity Limitation
ASHA	American Speech and Hearing Association
dB	Decibels
CHL	Conductive Hearing Loss
DQLS	Designing Quality Learning Spaces
FFR	Frequency Following Response
HI	Hearing Impairment
IQ	Intelligence Quotient
MLE	Modern Learning Environment
MoE	Ministry of Education
NZ	New Zealand
OM	Otitis Media
OME	Otitis Media with Effusion
PD	Professional Development
PDF	Portable Document Format
PR	Participation Restriction
RT	Reverberation Time

SFA	Sound-field Amplification
SNR	Signal-to-Noise Ratio

DEFINITIONS

It is important to note that the term Modern Learning Environment (MLE) is unique to New Zealand (NZ). Recently, the NZ Ministry of Education (MoE) has begun to refer to MLEs as innovative learning environments, due to this term being more consistent with international usage. The terms 'open-plan classroom', 'innovative learning environment' or '21st century learning environment' may be found throughout the duration of this thesis, and are both analogous with the definition of a MLE.

Break-out spaces	Small spaces which are used for smaller groups of students who are all focussing on the same task.
Didactic teaching	Teachers provide students with the required theoretical knowledge through face-to-face direct instruction. This is the typical method of instruction in single-celled classrooms.
Factory-style learning	Where all students learn the same things, at the same time, in lock-step fashion (Osborne, 2013).
Incidental learning	Not typically classroom-based or highly structured. This occurs as a consequence of other activities such as interpersonal interactions, trial and error experimentation or accomplishing tasks. It is the desired method of instruction in MLEs.
Knowledge-based economy	"Production and services based on knowledge-intensive activities that contribute to an accelerated pace of

	technological and scientific advance as well as equally rapid obsolescence" (Powell & Snellman, 2004, p. 201).
Modern Learning Environment	An environment that is capable of evolving and adapting as educational practices evolve and change therefore remaining modern and future focused. The term 'MLE' is analogous with 'innovative learning environment', 'open-plan classroom' and '21st century learning environment'.
Single-celled classroom	Traditional primary school classroom, set out as a learning space suitable for approximately 30 students. These are also referred to as 'traditional learning environments.

INTRODUCTION

1.0 The shifting pedagogy

The recent rise of globalisation and growth of digital technology has resulted in increased criticism of the relevance of the New Zealand (NZ) education system (Wilson, 2015). The permeating concern is that the NZ primary school system is based on an industrial model which is no longer suitable for the developing knowledge-based economy (Wilson, 2015). The industrial model of education arose towards the end of the medieval era in Europe due to the need for the provision of a labour-force who were literate and numerate, and therefore capable of factory work (May, 2011). This model of education monolithically processed students through the education system, and focussed predominantly on the teaching of reading, writing and arithmetic (May, 2011). The implementation of a defined grading system meant that the teacher focussed on students as being of a sole academic proficiency, subsequently creating the ideal that all students should be taught the same subjects at an equivalent pace, using identical methods (Horn & Evans, 2013).

As a consequence of international concerns regarding education, the Ministry of Education (MoE) created a report entitled 'Supporting future-oriented learning & teaching; a New Zealand perspective' which outlines emerging principles for future learning, the ways in which these are expressed in modern NZ educational practice and how these could project forward as future ideas (Bolstad et al., 2012). Amongst the concerns that modern education needed to extend beyond reading, writing and arithmetic to keep pace with the dynamic 21st century world, the findings highlighted the necessity of a dramatic system shift. This would renovate not only the pedagogy underlying the operation of schools but also modify the physical learning environments of school classrooms. As this transition is recommended by the MoE it is crucial that teachers are actively engaged in the transition process and kept informed regarding factors which influence children's learning. As such, potential alterations to classroom acoustics which will be created by modern classroom designs are an area to be monitored (Mealings et al., 2015).

Primary school children are particularly vulnerable to the effects of extraneous noise (Shield, Dockrell, & Rigby 2004). Classroom environments with excessive background noise and reverberation have the potential to negatively influence the development of reading and numeracy skills, as well as having adverse effects on overall academic performance (Mackenzie, 1999; Maxwell & Evans, 2000). Poor classroom acoustics contribute towards high levels of listening fatigue, poor attentive behaviour and degradation of the learner's memory capabilities (Anderson, 2004; Hicks & Tharpe, 2002). As teachers hold the majority of control over the daily management of the classroom space, it is essential that they are made aware of the importance of classroom acoustics for students' learning. The current 10 Year Property Plan (10YPP) which sets a 10-year schedule of property work, and the and resultant shift towards implementing Modern Learning Environments (MLEs) means that NZ classroom listening environments will be altered as a consequence of an increased number of open-plan classrooms. Therefore, it is essential that teachers are kept informed regarding methods and strategies which could be implemented to help utilise the acoustics of the classroom to their advantage. It is hoped that by improving teachers' knowledge of classroom acoustics, the level of unnecessary extraneous background noise children is exposed to will be reduced, which will have subsequent positive repercussions on students learning.

In order to thoroughly investigate teachers’ knowledge of classroom acoustics, background research must first be carried out with regards to the factors which influence the classroom environment and teachers’ knowledge of these. As such, the following literature review aims to define a MLE and explore the differences between these classrooms and traditional learning environments. Further to this, investigations regarding the associated ramifications these changes may have upon students’ learning will be made. The current status of MLEs in NZ will be explored, along with the benefits and challenges associated with implementing these environments. Though MLEs are becoming increasingly common in the NZ educational setting, they have not yet saturated the entire cohort of domestic primary schools and as such, the engagement of teachers’ surrounding this shift will be examined. As classrooms are settings which are influenced by a myriad of different noise sources, factors which influence the classroom listening environment will be discussed. As an extension of this, how teachers’ knowledge of classroom acoustics can impact upon the provision of a successful learning environment will also be explored. This review of the literature follows a narrative style; an approach that is one of a variety of accepted methods regarding literature review organisation (Rumrill, Ritzgerald, & Merchant, 2010).

LITERATURE REVIEW

2.0 Defining Modern Learning Environments

The official definition of a MLE in a NZ context is specified by the MoE (2015). This outlines a MLE as an environment that is capable of evolving and adapting as educational practices evolve and change, therefore remaining modern and future-focused (MoE, 2015). The term MLE is predominantly used to refer to school classrooms but may be extended to include any designated place of learning such as: science laboratories, distance learning contexts, libraries, tutoring centres, staffrooms, gymnasiums, and the interaction between these spaces (MoE, 2015). A learning environment may encompass the complete physical, social and pedagogical context in which learning is intended to occur (Wilson, 2015). The pedagogy underlying MLEs supports strength-based teaching and encourages flexibility, openness and access to resources (Osborne, 2013). Modern Learning Environments encourage the idea that working in an open and flexible learning environment will assist children in sharing ideas, working collaboratively, and embracing reflections based on self and peer observations (Osborne, 2013).

2.0.1 Different terms for Modern Learning Environments

Though the shift towards MLEs is recommended by the MoE in current domestic educational practices, a myriad of terms exist within the literature regarding the appropriate terminology which should be used to discuss these new environments (Amos, 2013). The term 'Modern Learning Environment' is used exclusively within the context of education in NZ. Similar classrooms constructed in Australia which foster the same educational concepts and principles as MLEs are referred to primarily as 21st century learning environments (Wilson, 2015). The paucity of a strong definition surrounding MLEs means numerous terms have been developed with analogous meanings. As such, in both domestic and international contexts MLEs are also referred to as innovative learning environments, flexible learning environments, and collaborative learning spaces. For the sake of consistency and clarity, the term MLE will be used throughout the following research to reflect the NZ context of this pilot study.

2.0.2 Modern Learning Environments in New Zealand

In NZ, the development of MLEs is the direct result of MoE policy (Benade, 2015). The plan to upgrade primary schools to MLEs was officially implemented in 2010 as part of the 10YPP process and five-year agreement funding. As the strategy to implement MLEs is overseen by the MoE, these changes will be applied irrespective of the personal desires of schools and their communities (Benade, 2015). Schools are required to progressively upgrade their teaching and learning spaces with the aim of all renovations being completed by the year 2020 (Wilson, 2015).

The first step involved in the transition process is to assess current school property against the MLE standard using the 'MLE school assessment tool' (Wilson, 2015). Schools are required to upgrade classrooms to the Designing Quality Learning Spaces (DQLS) standards published by the MoE in September 2016, which includes adequate acoustics, lighting, heating and ventilation (MoE, 2016). The upgrade and design of learning spaces owned by the MoE are regulated through three tiers. This means it is commissioned 1) nationally through Ministry programmes, 2) regionally via Ministry delivery managers and 3) locally by a Board of Trustees (BoT) (MoE, 2016). The MoE has ownership of approximately 30,000 buildings across 2,100

NZ schools (MoE, 2016). Each of these schools is therefore under the ownership of the Ministry regarding the design of their learning spaces. The intent behind the publication of these guidelines was to ensure that as educational spaces are modified to reflect modern teaching and learning pedagogy, they remain built to a standard of high acoustic performance (MoE, 2016).

2.0.3 Development of Modern Learning Environments

The current NZ curriculum was first developed in 1992, and acted as a framework for educational methods as opposed to a regimented teaching-focussed plan (Wilson, 2015). This traditional education model stipulated that the transmission of information was "something 'done' to students, rather than something that is interactive and co-constructed" (Wilson, 2015. p. 8). The present accessibility and necessity of digital technology has grown as a consequence of globalisation, and has resulted in the current knowledge economy (Wilson, 2015). A knowledge economy is defined as the "production and services based on knowledge-intensive activities that contribute to an accelerated pace of technological and scientific advance, as well as equally rapid obsolescence" (Powell & Snellman, 2004. p. 201). The rise of this phenomenon has resulted in increased criticism regarding the relevance of the traditional NZ education system (Wilson, 2015). This is because it is based on an industrial model which is no longer relevant to the requirements of modern education. In response to the rising concerns regarding the outdated nature of the NZ model of education, the MoE commissioned a report (Bolstad et al., 2012) which detailed appropriate philosophies for modern learning, the ways in which these are presently conveyed in domestic education and modifications which would be appropriate for the future.

The outcome of this report emphasised the necessity of a shift to change the physical environment in which learning occurs, evolving towards MLEs. This was deemed necessary as the majority of NZ primary schools were constructed during a period where the most effective pedagogy for learning was regarded as direct instruction, which orientated around the memorisation and subsequent regurgitation of knowledge, as opposed to a deeper understanding of the relevant concepts (Wilson, 2015). While this pedagogy is now outdated, many of the physical classrooms around NZ have not been updated to reflect this. This means they have largely retained their original design and hence, the suggestion of factory-style learning is retained (Wilson, 2015).

Historically, the definitions surrounding learning have been ambiguous and were often used to label an expansive range of cognitive phenomena (Wilson, 2015). Much of the research regarding knowledge about teaching and learning was tacit, meaning limited explanations were sought to clarify the rationale behind traditional learning methods (Wilson, 2015). Modern understanding of learning emphasises that educational outcomes are improved when teachers actively reflect upon how their teaching style influences the results of their students, and subsequently modify their practice to optimise outcomes for individuals (Aitken, Fraser, & Price, 2007). The recently developed, modern national educational framework which is to be implemented in MLE classrooms focusses on incorporating flexibility, which is deemed a necessary component of a successfully implemented MLE. This means support should be provided to assist in the personalisation of learning, which increases the level of choice given to the students. This includes linking learning and the assessment of knowledge to authentic contexts such as field trips and experiments, along with the increased prevalence of group-work (Wilson, 2015). The design of MLE classrooms rejects the traditional concept of a single-celled classroom. Instead, single-celled classrooms are combined to form a larger space containing flexible learning hubs which are characterised by large open spaces, permeable boundaries and open access to technology (Benade, 2015).

2.1 Characterising Modern Learning Environments

Modern learning environments facilitate modern teaching pedagogies in settings which offer both students and teachers increased openness, flexibility and access to resources. Further explanation for each of these constructs will be provided in the following section.

Openness

Traditionally, MLEs aimed to optimise their space through facilitating the use of a central learning common (or hub) which provides an open learning space which can be utilised by several classrooms (Osborne, 2013). This is typically provided through the use of more glass and fewer walls which provide opportunities for students and teachers to learn from others and subsequently be observed in return. The proposed benefit of openness is that access is provided to what students are learning in nearby areas so that teaching and learning have the potential to be complemented and enhanced (Osborne, 2013). This provides the opportunity for cross-curriculum collaboration, meaning that teachers who harbour strengths in a specific area may use these to support a wider range of students. Osborne (2013) supports this idea based on the notion that access to the work of colleagues supports the development of effective teaching practice much more efficiently than would occur in single-celled classrooms. This benefit provides positive educational repercussions for students. Research by Campbell, Saltmarsh, Chapman and Drew (2013) found that the sharing of teaching practices has encouraging benefits for students' learning outcomes. Nieto (2003) provided support for this view, stating that MLEs provide a successful means for teachers to 'continually rediscover who they are and what they stand for through their dialogue and collaboration with their peers' (Nieto, 2013. p.125). This sharing of knowledge has positive repercussions with regards to the collegiality of the teaching community. While openness refers to the physical design of a space, it also alludes to the openness required in teaching practice. The notion of teachers sharing their ideas and skills whilst working more closely with each other has become a crucial component in the movement towards de-privatising the classroom, which is essential if MLEs are to be implemented successfully (Campbell et al., 2013; Hill & Epps, 2009; Lieberman & Pointer-Mace, 2010).

Campbell et al. (2013) found that the rapid renovations of traditional classrooms into converted MLEs was resulting in a lag in the provision of necessary professional support required by teachers to be able to optimally utilise these environments. This research concluded that to facilitate a successful transition into a MLE, sufficient time and properly managed change were key elements. International research has acknowledged that the provision of MLEs are important in educating children in a way which is beneficial for the complexity and fluidity of the 21st century world (Jankowska & Atlay, 2008; Schneider, 2002; Woolner, McCarter, Wall & Higgins, 2012), however provision of the physical MLE itself solely at an architectural level will be unlikely to instigate successful change. In order to effectively utilise these spaces, teachers must be provided with adequate training, and all users of these spaces must foster a flexible attitude (Parnell & Procter, 2011). Optimal learning outcomes were achieved when both children and teachers experienced ways in which their new environment would be able to support their learning needs together (Parnell & Procter, 2011). Learning spaces must be flexible and orientated around the needs of students as opposed to being teacher-centred, and should also provide the necessary technology to meet both student and subject needs (Jankowska & Atlay, 2008; Scott-Webber, 2012; Wilson & Randall, 2010).

Flexibility

Flexibility is a term which encompasses many aspects of MLEs. All MLEs must be flexible, which means they should have the potential to combine two or more classes together into one large group, or alternatively split classrooms up into smaller focus groups. Flexibility should allow for groups of students to simultaneously focus on different tasks, meaning some students could be located in break-out spaces or targeted learning areas outside the classroom (Nair, 2014). As per the traditional design of MLEs, the central learning hub should be surrounded by flexible moveable partitions and break-out spaces which provide both teachers and students with options for group work and team teaching (Bissett, 2014). The MoE (2015) explained that flexible teaching spaces have the potential to expand or reduce in size based on the subject that is being taught and the subsequent technology requirements. As such, the installation of sliding glass walls is common, as these are useful in expanding or reducing the size of an environment. This type of classroom is designed to be student-focussed, as it allows for teachers to have more flexibility regarding the navigation of groups which students are working in.

Access to resources

The arrival of the 21st century has brought with it a huge increase in the availability and accessibility of digital technology. In response to this, MLEs should be constructed in a way that allows for greater incorporation of technology into the education system than what was historically utilised in traditional single-celled classrooms (Campbell et al., 2013). The breakout spaces within a MLE should contain a mixture of wireless and wired technology, which is made accessible to students with the goal of enhancing specific aspects of their learning (Osborne, 2013). Many secondary school classrooms, and an increasing number of primary school classrooms are adopting the Bring Your Own Device (BYOD) model, where students have their own tablet or laptop which they use as their primary method of note-taking and learning. In a study by Grayson (2010), mobile screen systems were described as being the most important tool to aid collaborative learning. This is largely due to the flexibility of this system, as students are able to plug in their devices to share their work with the class when necessary. Each school has different needs and levels of flexibility regarding the BYOD system, however, Wilson (2015) states that including technology in the classroom in some form is no longer optional.

Access to resources via technology provides students with the opportunity for global connection, which allows pupils an opportunity to develop their own methods of learning (Song, 2014). They hone and develop these skills over time in order to become lifelong learners. While the theory behind open access to resources has many positive repercussions, it has been highlighted that this must also be safely regulated (Madden, Wilks, Maione, Loader & Robinson, 2012). This regulation needs to include targeted professional development (PD) which should successfully support teachers surrounding methods underlying the implementation and inclusion of digital technology in the classroom, and support students in their endeavours to work with these tools. To gain the maximum benefit from the use of digital technologies in the classroom, spaces need to be flexible, open and adaptable to accommodate individual and group-based work.

2.2 Differences between traditional classroom environments and modern learning environments

2.2.1 The beginnings of education in New Zealand.

In an effort to develop a national education system, the Education Act was passed in 1877 which founded NZ's first free, secular and compulsory nationwide system for primary school education (Chapman, 1992). This act stipulated primary school attendance as mandatory for children between the ages of 7 and 13. Prior to this act being enforced, the majority of children attended schools which were regulated either by the church or through private funding. Whilst the Education Act was passed with the intention to educate all children, barriers remained regarding difficulties providing transport for children from rural areas, or children whose families maintained they needed their assistance around the farm for manual labour.

2.2.2 Traditional or 'Classic' learning environments.

Traditional classroom environments typically modelled a learning style based upon Thorndike's 1890's Behaviourism theory (Thorndike, 1898). Behaviourism stipulates that a learner essentially begins with a blank slate and that behaviour is shaped on top of this by means of positive and negative reinforcement (Petri & Mishkin, 1994). Consequently, this assumes that a student is essentially passive in the learning process and will respond to the material presented to them based on the reinforcement provided to their behaviour. Stringent adherence to a fixed curriculum was encouraged; the role of the teacher was directive and learning occurred as a result of repetition (Smerdon, Burkam, & Lee, 1999). Students worked individually as opposed to in groups and assessment primarily occurred through formal testing.

This method of learning was typically implemented in a single-celled classroom environment (Smerdon, Burkam, & Lee, 1999). The design of these environments modelled a rectangular space with rows of desks and chairs for all students learning within that room (Alsaif, 2015). The blackboard was situated behind the teacher's desk at the front of the classroom (Nair & Fielding, 2007). A method of behaviourism and direct instruction was used (Alsaif, 2015). This was a teacher-directed method where the educator stood at the front of the classroom and presented information directly across to the students (Alsaif, 2015).

2.2.3 Present models of education.

The shift towards a more modern style of learning was influenced by different educational theories which arose during the 19th century. The concepts orientated around the development of active learning and promotion of a constructivist education (Pardjano, 2016). The defining theories were Dewey's progressive education theory (Dewey & Childs, 1933), Piaget's theory of assimilation (Piaget & Cook, 1952) and Vygotsky's theory of the social context of learning and constructivism (Vygotsky, 1930), (Pardjono, 2016).

The traditional model of education has been condemned as being solely focussed on passive and receptive learning (Dewey, 1933). Instead, it was proposed that for the successful acquisition of knowledge and skills, children must be physically and mentally involved in the action of learning (Dewey, 1933). Learning occurs when personal experiences are modified based on information learned from past situations, resulting in understanding for future situations and the continual reconstruction of thought processes (Pardjono, 2016).

In the context of human learning, the ability to adapt to one's environment results in cognitive development. This is a two-fold process made up of assimilation and accommodation

(Pardjono, 2016). Assimilation is the intellectual process during which the individual accommodates to their environment based on their pre-existing cognitive schemas (Pardjono, 2016). Accommodation is the process of changing one's existing way of thinking as a response to a new event or stimulus (Royer and Feldman, 1984). This essentially means that humans have the ability to modify their knowledge and behaviours to adjust to new stimuli in their environment. When active learning occurs, a series of principles should be adhered to (Pardjano, 2016). The first of these is that learning should be student centred and individualised (Pardjano, 2016). Secondary to this, students learn best when they are actively engaged in the learning process, which means that social interaction and group work need to have an essential role in the classroom. This will enable children to construct their knowledge in a way which has personal meaning (Pardjono, 2016).

Vygotsky's (1978) viewpoint adds the importance of structured guidance to the learning theories described above. This critical part of learning is defined as the zone of proximal development. This is defined as "The distance between the actual developmental level as determined by independent problem solving and level of potential development determined through problem-solving under adult guidance" (Vygotsky, 1978. p. 86). This explains the area between the tasks a child can successfully perform alone and the tasks which require adult guidance. When a child is in this territory, they are susceptible to being influenced by those around them - meaning this is the optimal stage for the facilitation of learning (Pardjono, 2016).

An amalgamation of these theories has brought about the current focus for modern teaching pedagogies to be implemented in MLEs. In these settings, the interaction between students and teachers is reciprocal so that both parties are senders and receivers of knowledge. The role of the teacher is to guide students in an environment which is conducive to promoting creative thinking, social interaction and the solution of cognitive conflicts (Weil, Murphy, Hallinger, & Mitman, 1982). Modern learning environments differ from traditional classrooms as they aim to facilitate a range of teaching pedagogies such as creating, communicating and decision-making (Osborne, 2013).

2.3 Incidental models

Modern learning environments are not yet a universally-recognised movement (Benade, 2015). It is argued that there is a lack of evidence to support the global implementation of the shift towards this modern style of learning (Benade, 2015). The progression of educational methods through to the 21st century has brought a shift in international perspectives regarding teaching and learning methods (Fraser & Hill, 2015). This movement has been underpinned by immense social, economic and technological change, which has prompted a reconsideration of ideas around the purpose of education in a world which has an exceptional degree of fluidity and complexity (Fraser & Hill, 2015).

Perkins (2009) explained that individuals do not learn effectively as passive recipients of knowledge verbally imparted upon them by an expert. Instead, it was hypothesised that successful scholarship results from active engagement in the learning process through interpersonal interactions and dynamic participation. This is a principle that appears to be well-accepted by teachers (Perkins, 2009), however, the traditional education system was not structured in a way conducive to applying these values in practice (Perkins, 2009). Recognising this was the first step in building an innovative education system with a knowledge-accessible focus (Fraser & Hill, 2015). The second step consists of providing sufficient public support for teachers and school leaders whilst this paradigm shift is implemented (Fraser & Hill, 2015).

New Zealand remains in sync with international practice with regards to its all-inclusive approach to mainstreaming students with special needs (Kearney & Kane, 2006). Specified support systems are allocated according to the needs of the individual (Kearney & Kane, 2006). Historically, NZ held international success regarding high standards of literacy (Guthrie, 1981). Recent years have seen this negatively change and lower literacy rates among Māori and Pacific Island ethnic groups have increased (Marriott & Sim, 2014). This has led to discussion regarding which method of teaching will best-support refining literacy levels for all NZ children and youth.

Modern teaching pedagogy is also known as incidental teaching, and incorporates an increase in small group work and secondary or passive learning opportunities. Incidental teaching involves a significant amount of verbal-social interaction (Nelson & Soli, 2000). As a child's language expertise increases, their passive learning also increases, as a result of being able to listen to, and understand the conversations occurring around them (Ling, 1988). Incidental learning models assist children in monitoring environmental events and recognising social cues (Flexer, 1997). The development of these skills encourages meaningful communication in the classroom and increased language and literacy development. NZ primary school students spend approximately 4 to 5 hours per day inside the classroom (Valentine, Wilson, Halstead, McGunnigle, Dodd & Hellier, 2002). Of this, 69% of teaching time is allocated to group or mat work, while only 12% is dedicated to didactic teaching (Valentine et al., 2002). As robust reading skills are not usually present until approximately the fifth year of education (Matkin, 1996), it is crucial for children to receive information via a consistently strong acoustic signal, in order to better facilitate understanding of the verbal instructions presented by their teacher.

2.4 Consumers of Modern Learning Environments

Following the above explanation of the fundamental underlying concepts of MLEs, the next area necessitated within this review is to investigate the needs of MLE consumers. In NZ, primary schools educate children between the ages of 5 and 11 years old. Consequently, the following section aims to explore the ways in which children develop a functional lexicon and cohesive speech. The following section will also investigate common causes of fluctuating hearing loss in children, which exposes them to the risk of receiving an incomplete auditory signal. This explanation will give further context regarding the necessity for children to receive clear acoustic signals during their key developmental stages, and how MLEs or poor classroom listening environments may impact upon this.

2.4.1 Functional lexicon and speech development.

To successfully develop a functional lexicon, children must learn to form accurate representations of the speech sounds present in their surrounding environment (White-Schwoch et al., 2015). Children growing up in today's dynamic situations often have to strive to hear speech signals over superfluous industrial and environmental noise (White-Schwoch et al., 2015). The often unstable and fluctuating nature of the acoustic environment is challenging for those in early childhood, as this is the period during which they must learn to understand their soundscape (White-Schwoch et al., 2015).

2.4.2 Central auditory processing.

Central auditory processing may develop in a heterogeneous manner, depending on the acoustic nature of the learning environment and the child's access to clear auditory signals (American Speech-Language-Hearing Association [ASHA], 1996). The age of the child can also be a factor, meaning that the younger the child is, the more susceptible they are to the detrimental effects of background noise on speech perception (Hall III, Grose, Buss & Dev, 2002; Leibold & Buss, 2013; Wightman & Kistler, 2005).

A child's vulnerability to being negatively-influenced by the effects of background noise on speech understanding decreases with age. This is because throughout childhood and into adolescence, the cortical areas of the brain continually thicken as neural connections proliferate (Johnson et al., 2009). Evidence from longitudinal neuroimaging studies shows that the adolescent brain continues to become neuro-mature until an individual is in their late twenties (Johnson et al., 2009).

Lack of successful auditory mapping has been found to be associated with childhood learning problems and consequent communication issues, which may influence such abilities through to adulthood (Bradlow, Krauss, & Hayes, 2003; Cunningham, Nicol, Zecker, Bradlow, & Kraus, 2001; Ziegler, Pech-George, George, & Lorenzi, 2009). Further to this, children with central auditory processing disorders and hearing problems without a clearly identifiable underlying neuropathology will likely present benign neuroanatomic issues. These are underlying to auditory issues or maturational delay due to the slower course of myelination or auditory deprivation (Chermak & Museik, 2011).

2.4.3 Childhood speech processing.

A child's ability to process speech in the presence of background noise can be measured using the auditory-frequency following response (FFR). The FFR depicts the neural activity required for auditory perception in noise (Kraus et al., 2000; Zeng, Oba, Garde, Sininger, & Starr, 1999) and occurs as a product of synchronous firing from the midbrain nuclei. Heightened subcortical neural synchrony is associated with enhanced speech perception in difficult listening environments (Anderson, White-Schwoch, Parbery-Clark, & Kraus, 2013; Bidelman & Krishnan, 2010; Song, Skoe, Banai, & Kraus, 2011). Minor dyssynchronies are considered reflective of ineffective auditory processing in reverberant environments (Anderson et al., 2013).

While the FFR highlights the underlying neurophysiology associated with auditory perception, it also has the potential to measure the midbrain coding of different acoustic properties of the speech signal (White-Schwoch et al., 2015). Depending upon the stimulus used to evoke a response, the FFR contributes information pertaining to the temporal fine structure and formants of an individual's speech, which provides information regarding phonemic identity (White-Schwoch et al., 2015). Different aspects of speech are perceived differently when exposed to the presence of background noise (White-Schwoch et al., 2015). Due to consonants consisting of fast-changing spectral content and low amplitudes, they are at risk of being masked by surplus, external noise (White-Schwoch et al., 2015). This makes consonants more difficult to distinguish than vowels in the presence of background noise, as vowels are typically voiced at a higher intensity (White-Schwoch et al., 2015).

2.4.3.1 Factors impacting speech cues.

Cunningham et al. (2001) described that in pre-school and young children, the neural coding of transient and dynamic speech cues is attenuated in noisy conditions when compared to quiet conditions. Using near-field multi-unit recordings in animal models, Cunningham, Nicol, King, Zecker, and Kraus (2002) were able to show that the presence of background noise places neurophysiological constraints upon the auditory midbrain, thalamus and cortex of young children's brains, which detrimentally affects their ability to process consonant sounds. Children who experience listening difficulties may be assessed as having a developmental delay (Wright & Zecker, 2004), when the underlying reason is compromised auditory-temporal processing and difficulties parsing signals in noise (Sperling, Lu, Manis, & Seidenberg, 2005).

Research with pre-schoolers (aged 3-5 years) by White-Schwoch et al. (2015) found that FFR responses to a consonant-vowel syllable had a weaker response quality in the presence of background noise as opposed to in quiet conditions. The presence of background noise had a greater effect on the auditory perception of consonants, therefore proposing that consonant-in-noise processing is neurologically more susceptible to masking than vowel-in-noise processing (White-Schwoch et al., 2015). The physiological constraint that background noise places on listening during early childhood is relevant to the changing NZ primary school environment. As mentioned previously, the MoE is currently implementing a shift towards state-owned primary schools operating as MLEs. The rationale for embracing this shift in teaching pedagogy is supported by the need for continuous improvement in the educational setting (Bolstad et al., 2012), however associated with this movement is the probability that students' learning will be negatively impacted by increased levels of background noise as a consequence modifications to the traditional design of the classroom, and due to enlarged class sizes.

2.5 Incidental learning and hearing impairment

2.5.1 Incidental learning.

The majority of learning in NZ primary schools is facilitated through hearing and listening opposed to the didactic teaching model used overseas (Wilson et al., 2002). Marsick and Watkins (2001) defined incidental learning as "not typically classroom-based or highly structured, where control of learning rests primarily in the hands of the learner" (Marsick & Watkins, 2001. p. 25). Incidental learning occurs as a consequence of other activities such as interpersonal interactions, trial and error experimentation, or by accomplishing tasks.

Optimal learning conditions are present when a child is able to receive a clear acoustic signal from their teacher (Brackett, 1997). Regardless of the nature of hearing loss (conductive, sensorineural or mixed) and irrespective of the degree of the hearing loss, children with a hearing impairment need better acoustics than normal hearing students for speech understanding (Valentine et al., 2002). Over 90% of children with permanent, sensorineural hearing loss are allocated to the mainstream education system in NZ (Valentine et al., 2002). This means primary school classrooms often have a high number of hearing-impaired students (Valentine et al., 2002). The incorporation of a large portion of hearing-impaired students into the mainstream education system ensures a need for teachers to be knowledgeable about the influence that hearing may have on a child's learning, as well as the role the acoustic environment plays in achieving optimal outcomes for students. The nature of hearing loss has the potential to vary dramatically between each affected individual and as such, certain types of hearing loss more greatly affect specific populations than others. Consequently, the causes of hearing impairment which frequently affect young children will be discussed below, along with the resultant effects this may have on both their short-term and long-term learning outcomes.

2.5.2 Hearing Impairment.

Hearing loss can be considered an invisible challenge which means its effects are often unclear and challenging to conceptualise, particularly for others not affected (Ross, 1991). As children with hearing loss are at increased risk of responding incorrectly to instructions, being inattentive or distracted, or having a lower level of language and reading ability, their behaviour is often misconstrued and associated with learning or behavioural problems (Brackett, 1997).

A hearing impairment may act as an invisible acoustic filter which impedes incoming sounds (Ling, 2002). While the speech signal may remain audible despite the decreased intensity caused by a hearing deficit, a signal distortion that is introduced due to hearing loss results in the smearing or filtering out of speech phonemes (Flexer, 2004). Such distortion causes a decrease in the child's ability to accurately perceive speech sounds which negatively affects their ability to cultivate a robust memory of phonological word representations (Flexer, 2004). Ross (1990) stated that even a slight hearing loss has detrimental repercussions regarding literacy skills and academic progression. The nature and degree of a hearing loss has many variants among individuals, however, the most common cause of a temporary fluctuating or mild hearing loss in children is otitis media (OM) (Flexer, 1997).

2.6 Otitis Media

Conductive hearing loss (CHL) transpires when an obstruction prevents the transmission of sound through the external or middle ear (Hartley & Moore, 2003). The predominant cause of conductive hearing loss in children is OM (Bluestone & Klein, 2001). Otitis media is the inflammation of the middle ear, associated with middle ear effusion (Berman, 1995). This can have effects on the mucous membrane encompassing the middle ear cavity, mastoid air cells, mastoid antrum and the Eustachian tube (Ibekwe, 1999). Otitis media can be caused by bacteria or viruses and is recognised clinically, typically due to visual otoscopic inspection or immittance audiometry tests (e.g., tympanometry) which help to confirm the presence of inflammation and/or the likely presence of fluid in the middle ear space (Bluestone & Klein, 2001).

Otitis media is an umbrella term encompassing numerous conditions which have a detrimental effect upon the middle ear (DeAntonio, Yarzabal, Cruz, Schmidt, & Kleijnen, 2016). Acute otitis media is characterised by its sudden onset and brief duration, accompanied by the presence of fever, concentrated pain and pressure within the affected ear (Bluestone & Klein, 2001). Fluid may remain within the middle ear cavity after an acute infection has ceased. This may be due to the lingering presence of acute infection or as a consequence of the level orientation of the immature Eustachian tube (Winskel, 2006). The enduring presence of fluid within the middle ear cavity is often termed otitis media with effusion (OME), which can result in the prolonged presence of CHL and inhibits the efficient transmission of sound waves to the cochlea (Winskel, 2006).

A reduction of air pressure in the middle ear space coupled with fluid retention results in a hearing loss which fluctuates between 15 and 40 decibels (dB) (Bluestone & Klein, 2001). The extent of the hearing loss is not governed by the volume of fluid within the middle ear space; instead it is the viscosity of the effusion or the magnitude of fluid which influences the tension against the middle ear mechanism (Bluestone & Klein, 2001). The majority of fluid associated with OM will resolve without intervention in approximately one month (Winskel, 2006). However, it can remain for approximately two months for 20% of children, whilst 10% of children will continue to be affected after three months (Winskel, 2006).

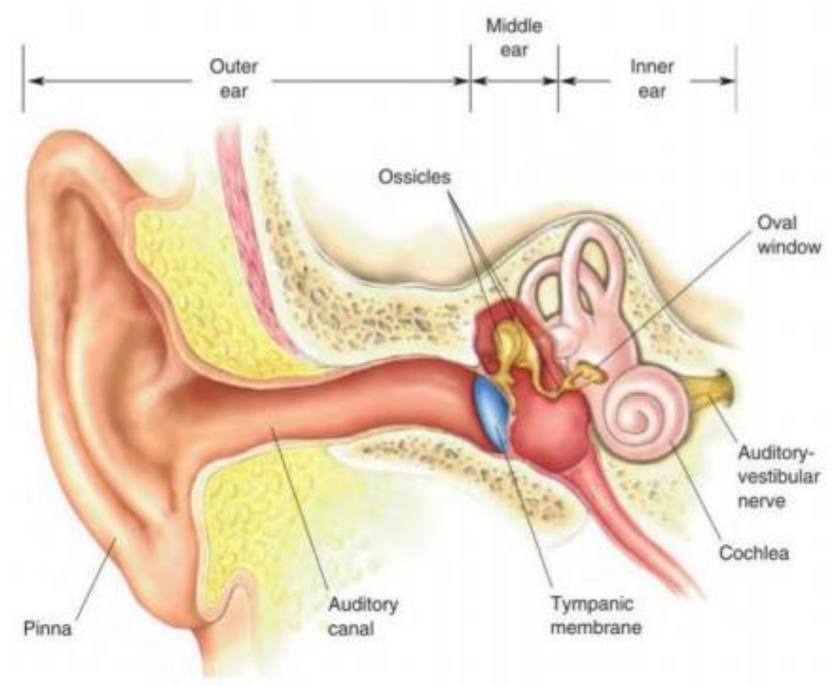

Figure 1: Anatomical features of the outer, middle and inner ear (Bear, Connors & Paradiso, 2007, p. 344).

2.6.1 Otitis media and academic outcomes.

A NZ study by Silva et al. (1982) examined whether any noticeable difference existed regarding speech articulation, language and motor development between children with bilateral OME, compared to children without a history of otological complications. It concluded that those with bilateral OME were at a significant disadvantage regarding their speech articulation, verbal comprehension, motor development and overall IQ levels. In conjunction with this, it was also noted that children with bilateral OME displayed higher levels of behavioural issues than those without OME (Silva et al., 1982). This was a longitudinal study, and the same cohort of participants were used by Bennett, Haggard, Silva and Stewart (2001), who proposed that the ramifications of early OME may perpetuate into teenage years, for affected individuals. The most predominant deficit was apparent in reading ability, with difficulties carrying into late childhood and early teenage years. After regulating the covariates to accommodate for socio-economic status and hyperactive, inattentive behaviour, it was found that difficulties remained evident as late as 15 years of age. In addition to this, lower Intelligence Quotient (IQ) associated with OME continued to be significant until 13 years of age. A similar study discovered that children with enduring or recurrent middle ear infection accompanied by mild, fluctuating CHL up to the age of five, had an increased likelihood of developing delayed reading skills when compared to children not affected by middle ear effusion (Golz et al., 2005). Further to this, it was reported that children with a recurrent history of OM achieved lower scores when assessed on their reading, expressive vocabulary and word definition skills, when compared to children with no history of middle ear effusion (Winskel, 2006).

Three different cognitive tests were used to provide IQ outcomes for the participants involved in the above studies. These included the verbal and non-verbal IQ at 11 and 13 years (using the Wechsler Intelligence Scale for Children, scale 12), the Dunedin spelling tests at 11 and 13 years, and the Burt Reading Test at 11, 13, 15, and 18 years. The Burt Reading Test was used up to age 18, as cohort members were already familiar with the test and it had been proven to be a reliable and valid index of reading ability (Silva et al., 1982). Intelligence quotient determination was assessed based on aged norms for each respective test result. The recycling of participants between studies can be a difficult factor to contend with in longitudinal research, as failure to retain participants poses a major threat to the validity of longitudinal research due to non-random attrition. This means that people who discontinue participating or are difficult to re-assess are typically not a random group of participants. Instead, this subset of participants tends to be people for whom multiple difficulties are aggregate. Therefore, it is important they be retained in order to accurately capture the full range of life exposures and possible outcomes that occur within the general population. Fortunately, the aforementioned longitudinal studies (Bennett et al., 2001; Silva et al., 1982) had excellent retention rates, with all but one of the 12 assessments conducted since birth retaining participation rates well above 90 % (Poulton, Moffitt, & Silva, 2015).

Despite the conclusions drawn in these studies, the resultant findings are not unequivocal. Feldman et al. (1999) was unsuccessful in linking recurrent early childhood OME to delayed language development in the first three years of life. These findings were consistent with those from a similar study from Paradise et al. (2000). Johnson (2000) and Roberts et al. (1989) found that recurrent OME in early childhood years did not result in lower results for language skills in early primary school years nor did it influence academic achievement during this same developmental period.

The ambiguous conclusions drawn in the literature may be a consequence of variance in study design (Roberts, Burchinal, & Zeisel, 2002). Limited studies have investigated the fluctuating nature of hearing loss associated with OME as a predictor variable. The severity of hearing loss related to OME can oscillate between normal hearing levels to a moderate hearing loss of 50dB. Another confounding influence is that the status of the child's home situation was not a well-documented factor in previous studies. The role of the caregiver in creating a nurturing home environment is integral when considering a child's language development and their resultant academic skills (Hart & Risley, 1995). As a final point, there is a limited amount of research which investigates these same outcomes longitudinally. While a finding may be relevant at one stage of a child's academic growth, this relationship may fail to be significant as the child ages and progresses (Roberts et al., 2002).

The education of children with a hearing impairment is an issue which is causing increasing concern amongst both audiologists and educators (Eriks-Brophy & Whittingham, 2013). This is due to the fact that though these children do not hear normally, they are not Deaf. This means educating these children is complicated by the broad spectrum of hearing abilities within this population (Eriks-Brophy & Whittingham, 2013). As such, some of the common impacts which different degrees of hearing impairment have on both receptive and expressive language skills, along with the effects on activities and participation are shown in Table 1 on the following page.

Table 1: The impact of varying degrees of hearing impairment.

Degree of HI	***Receptive language***	***Expressive language***	***AL/PR***
Normal hearing (0-15 dB HL)	Detects all speech signals	Normal range	None
Slight HI (16-25 dB HL)	Misses up to 10% of speech sounds (e.g. unvoiced consonants) especially in difficult situations	Mild dysfunction in language learning	Inappropriate response to sound Learning difficulties Poor social interaction
Mild HI (26 – 40 dB HL)	Misses 25-40% of speech especially in difficult situations	Mild language acquisition lag and speech problems	Inattention Learning difficulties Behaviour problems
Moderate HI (41 – 55 dB HL)	Misses 50-75% of speech	Moderate language acquisition lag and poor speech intelligibility	Learning dysfunction Significant social problems
Moderately – severe HI (56 – 70 dB HL)	Misses 75 – 100% of speech	Severe speech problems and language acquisition lag	Severe learning dysfunction Stigmatisation and possible social isolation
Severe HI (71 – 90dB HL)	Misses up to 100% of conversational speech	Severe speech problems and language acquisition lag	Severe learning dysfunction Stigmatisation and possible social isolation
Profound HI ((≥91 dB HL)	Misses all loud speech sounds except vibrations	Visual cues essential for communication	Complete social isolation

Note: Common impact of varying degrees of hearing impairment (HI) on receptive and expressive language skills and activities and participation. AL= Activity limitation, PR= participation restriction (Olusanya & Newton, 2007, p. 1314).

The knowledge held by regular classroom teachers with regards to hearing disorders and educating students who are hard-of-hearing was investigated in a study by Martin, Bernstein, Daly and Cody (1988). Of the 187 teachers included, the responses were indicative of a mean number of 9.77 of the 17 items in the knowledge section being answered correctly (57.4%). This result suggested that members of the sample population were not very knowledgeable about hearing impairment and the related considerations (Martin et al., 1988). These findings differed to those found by Eriks-Brophy and Whittingham (2013) who aimed to investigate whether teachers had the attitudes, knowledge and teaching skills required to effectively include hearing impaired students within mainstreamed education. This sample population indicated confidence in their ability to teach hearing impaired students as they felt knowledgeable regarding the effect that hearing loss has upon language and learning (Eriks-Brophy & Whittingham, 2013).

The disparity in the opinions of teachers between these two studies could perhaps be explained by the information teachers were provided regarding the hearing impairments of children in their classrooms. In the study by Martin et al. (1988), it was found that extent of their students' hearing impairments was never explained to 20% of the respondents, whereas 58% of the respondents reported that the extent of impairments was sometimes explained and 22% said it was always explained. Teachers in the study by Eriks-Brophy and Whittingham (2013) were not asked whether their students hearing impairments were explained to them, however, they were asked about the degree of hearing loss their hearing impaired students had. The knowledge teachers' held regarding the distribution of the degree of hearing loss of their students was 5% with mild hearing loss, 13% with a moderate loss, 14% with moderate to severe hearing loss, 43% with profound loss, and 25% with a degree of loss not specified. Compared to the knowledge of teachers in the study by Martin et al., (1988), these teachers appear to be better informed regarding the nature of their students hearing loss. This may be attributed further to the fact that for teachers in the study by Eriks-Brophy and Whittingham (2013), support services were provided to both the integrated students with hearing loss and their teachers, with 68.3% of teachers reporting that their students were seen on a weekly basis and 31.7% reporting that their students received support services at least three times per week (Eriks-Brophy & Whittingham, 2013).

Despite those who participated in the study by Eriks-Brophy and Whittingham (2013) indicating they felt knowledgeable regarding the effect that hearing loss has upon language and learning, these participants also clearly indicated that their teacher training programs had insufficiently prepared them to teach students with hearing impairment effectively. These findings emphasise the need for further PD and support for teachers regarding the educational needs of students with hearing loss throughout their training period, along with the provision of appropriate supports for both teachers and students to promote successful inclusion of hearing-impaired individuals (Eriks-Brophy & Whittingham, 2013).

Keeping teachers informed regarding their students hearing loss is especially important for teachers of young children, as OM is one of the most predominant childhood illnesses, with approximately 80% of children being infected up to 4 years of age (Klein, 1980). These years, and the early years of primary school, are critical for the acquisition of language, and it is during this period that the basis for future literacy and numeracy skills are developed (Roberts et al., 2002). Auditory processing skills, attention, behaviour, speech and language are all areas of cognition perceived to be most detrimentally affected by a hearing loss due to OM (Jacobs & Williams, 2009). With such a high percentage of children being compromised auditorily in early childhood, it is crucial that the primary school classroom provides sufficient isolation from superfluous noise. This is so that children who may have been detrimentally affected by a weak auditory signal at a younger age are not continuously placed at risk of excessive background noise during their early schooling years.

2.7 Benefits and challenges of modern learning environments

2.7.1 Benefits.

Research was carried out to determine whether there was any evidence that MLEs had positive effects on learning outcomes. Barrett, Zhang, Davies and Barrett (2015) conducted a study of 153 classrooms across 27 primary schools throughout the expanse of the United Kingdom. The purpose of this was to investigate the impact of the physical classroom on students' academic progress. The three parameters of naturalness (light, temperature and air quality), individualisation (ownership and flexibility) and stimulation (complexity and colour) were researched (Barrett et al., 2015). The findings supported the concept that the physical design of the classroom does indeed have an impact on student performance. In particular, naturalness accounts for half of the learning impact, while simple changes in the classroom design can account for 16% of a student's progress over the course of a year. These conclusions provide solid evidence that built-in environmental factors have a significant impact on student performance. This opens avenues for funding design upgrades, as it proves that the impact of building design on human performance is isolated and significant (Barrett et al., 2015). Despite this, it does not conclusively prove that MLEs will result in these same outcomes. If built in a similar design which promotes a high degree of naturalness, individualisation and stimulation, similar benefits may be witnessed; however without these factors, the provision of an MLE alone will not automatically improve student outcomes.

An American-based meta-analysis by Schneider (2002) reviewed studies to investigate whether school facilities affect academic outcomes. These findings supported those of Barrett et al. (2015) by concluding that improving physical school facilities positively affects student learning. It was shown that spatial configurations, noise, heat, cold, light and air quality all have an influence on both students and teachers ability to perform (Schneider, 2002).

The benefits of MLEs are that they aim to assist students towards becoming independent, self-directed and successful learners (Baker, 2013). A successful self-regulating learner is capable of utilising their cognitive abilities to set goals, develop plans and monitor their own learning progress through self-evaluation (Baker, 2013). Break-out areas provide physical spaces where children can work unsupervised, which requires a high amount of self-direction and responsibility (Osborne, 2013). In this environment, teachers are provided with the opportunity to scaffold the learning environment in the way that they determine most appropriate for optimal student achievement. This promotes experiential learning, where students have the opportunity to learn through guided action (Gentry, 1990). It has been proposed that in traditional environments where the teacher controls all aspects of learning, self-regulation becomes restricted and children do not learn to become autonomous learners (Clark & Svanaes, 2014; Madjar & Assor, 2013).

Despite the improvements to physical school facilities described above, simply converting a classroom into a MLE does not necessarily imply that the teaching pedagogy will match this system. Hattie (2009) highlighted that although a MLE may have been implemented in the physical sense, this does not guarantee that the principles of modern teaching are being utilised within that space. This means, that while MLE education has strong intentions with regards to its underlying rationale for supporting autonomous learning, the actual implementation of this is often widely varied. Despite this, research has shown that modern teaching pedagogy in

MLEs tends to raise student performance with regards to improving self-concept and positive attitudes (Hattie, 2009). While it has been determined that the physical environment has a significant impact on student learning, it has been found that teachers who have a deeper understanding of student centred learning environments and constructivist learning are more likely to create positive and successful learning environments (Paltridge, 2009). This finding provides support for the necessity of assistance and training for teachers regarding how to convert their teaching practice towards being conducive to a MLE setting.

As MLEs are often associated with increased levels of background noise, Maxwell and Evans (2000) investigated the relationship between ongoing noise exposure and reading skills for those in early childhood education. In order to measure this, sound level measurements were used to establish the acoustic quality of the classroom. Participants learning in a poor acoustic environment undertook a cognitive measure of pre-reading skills. Subsequent to the application of acoustic treatment, these same tests were repeated in an acoustically treated classroom the following year. It was found that participants educated in the quieter classroom environment achieved better scores than those tested prior to the acoustic treatment of the classroom. When considering the applicability of the findings by Maxwell and Evans (2000), consideration must be first given to potential confounding factors which were raised in a critical appraisal by McLaren and Page (2016). Questions were raised regarding the efficiency of the chosen method of acoustic treatment. All certified acoustic treatment materials are assigned an acoustic rating known as a noise reduction coefficient. McLaren and Page (2016) suggested that including the noise reduction coefficient of the acoustic treatment used by Maxwell and Evans (2000) would have provided more robust information for consumers who may be considering the installation of similar acoustic treatment within their facilities (McLaren & Page, 2016). Further to this, as dBs are measured on a logarithmic scale, McLaren and Page (2016) also raised concerns regarding the accuracy of the statistical analysis. It was offered that the analysis may have been improved had the dB values been converted back to their linear equivalents prior to performing the analysis. An additional confounding factor was raised with regards to how the classroom activities both before and after the acoustic treatment were controlled for (McLaren & Page, 2016). The level spontaneity in a primary school classroom environment is high, and students are unlikely to generate the same amount of noise across different days. Additionally, absenteeism rates were not documented within the study by Maxwell and Evans (2000), which may have affected the overall noise levels within the classrooms across different testing days (McLaren & Page, 2016).

2.7.2 Challenges.

The research supporting the implementation of MLEs is often associated with the benefits of the physical design of the learning environment as opposed to the teaching pedagogy within MLEs. Wall (2015) found that there were no consistent findings as to whether open-learning spaces had a positive or a negative impact on student engagement and achievement. It can be determined that the lack of conclusive evidence may be a consequence of variation between the different types of teaching and learning programmes being implemented, as due to the flexible nature of MLEs it is possible to accommodate a range of different methods of instruction (Osborne, 2013).

Comprehensive international studies throughout the 1970's investigated the effectiveness of open-plan teaching in comparison to traditional didactic models (Horwitz, 1979; Peterson, 1979). These reviews recognized that children who were taught using direct instruction achieved slightly improved academic achievement on tasks than children learning under open-plan teaching methods. However, this improvement was not consistent across all subjects. It was concluded that those instructed under the open-plan approach achieved slightly better scores on to tasks orientating around creativity, problem-solving, abstract thinking, attitudes towards school, independence, curiosity and attitudes towards teachers (Horwitz, 1979; Peterson, 1979).

Peterson (1979) also identified the importance of the teacher's ability to understand the needs and motivations of their students within the classroom environment as a critical factor in successful learning. Students who are high-achieving, task-orientated learners tended to perform more successfully in open-plan environments operating under a student-directed approach (Peterson, 1979). On the contrary, when students were receiving lessons focussing on basic literacy and numeracy skills, a method of direct instruction was found to be most conducive to successful learning (Peterson, 1979). As a consequence, it was recommended that in order to achieve optimal outcomes for each student, teachers would require specific training to learn how to best utilise their evolving workspaces (Cameron & Robinson, 1986).

Principals and teachers with previous experience working in open-plan environments were approached for comment regarding their views of the effectiveness of the MLE classroom style (Department of Education, 1977). Concerns were raised for "…shy and (or) aggressive pupils; for new entrants and emotionally disturbed children" (Department of Education, 1977. p. 93) regarding how well they would be able to assimilate and flourish in such a dynamic setting. To counter this, the Department of Education (1977) recommended that each open-plan classroom should be equipped with several break-out spaces, of which, one must be large enough to accommodate up to 15 students, their teacher, and the necessary educational resources.

Teachers have reported significant challenges associated with working in open-plan spaces (Cameron & Robinson, 1986; Department of Education, 1977; Cuban, 2004). The predominant challenge reported was lack of adequate support and preparation for working in an open-plan environment. Following this, challenges also reported were: lack of appropriate storage space, lack of space for teachers to plan, inadequate systems to support the collaborative practice, and difficulties managing excessive noise levels (Cameron & Robinson, 1986; Cuban, 2004). In addition to this, reports were received that teachers experienced higher stress levels as a result of having to continuously collaborate with, and be observed by others, whilst maintaining control of a larger number of children (Cameron & Robinson, 1986).

The Oticon Study was commissioned as a result of complaints relating to the acoustic properties of relocatable classrooms (Valentine et al., 2002). As part of this, teachers were asked to rate their classroom listening environment on a scale from 1 being 'very good' to 5 being 'very poor'. The average rating was concluded to be 2.8, which is indicative of an 'acceptable' rating. Only a small percentage (7%) of teachers rated the listening environment as 'very good'. The majority (34%) of participants rated their classroom listening environment as 'acceptable', though this was closely followed by a similar percentage (32%) who rated their classroom listening environment as 'good'. Negative ratings also featured, with 21% of participants selecting 'poor' and 6% selecting 'very poor'. Those who selected negative ratings were asked to elaborate further with regards to their reasoning behind this. The majority listed 'too much echo' (Valentine et al., 2002. p. 14), and 'noise level produced by students too high' (Valentine et al., 2002. p. 14) or cited noise from outside the room as the predominant issue rather than choosing open-plan rooms as the primary reason for raised noise levels (Valentine et al., 2002). An important aspect to note was that it was not differentiated or discussed which ratings were assigned by those teachers working in traditional learning environments and which came from teachers working in MLEs. Further to this, there was only a small number of open-plan rooms were included in the study. This was because many of the open-plan rooms in the schools involved in the study had been converted back to single-celled, traditional learning environments. As a consequence of these limitations, a useful area of future research arose regarding investigating whether a difference exists between teachers' ratings of their classroom listening environment depending on whether they teach in a traditional learning environment or in a MLE. Therefore there is a need to better understand whether teachers of MLE classrooms rate their classroom listening environment as poorer than teachers in traditional classrooms and which noise sources have a detrimental effect on the classroom listening environment.

2.8 Factors influencing the classroom listening environment

2.8.1 Classroom acoustics and variables influencing listening ability in the classroom.

In order for students to reach their optimal level of academic achievement, it is imperative that they receive accurate transmission of the acoustic signal (Crandell & Smaldino, 2000). Therefore it is important that teachers possess the knowledge and skills to understand classroom acoustics, the variables which influence listening ability in the classroom and the resultant effects these factors may have on children's learning. The classroom is predominantly an auditory-verbal environment where learning occurs as a result of successful listening and understanding (Hodgson & Nosal, 2002). The clarity of the speech signal has the potential to be detrimentally affected by the acoustic design of the classroom. Factors such as distance, reverberation time (RT), background noise levels and signal-to-noise ratio (SNR) have the potential to compromise speech recognition (Crandell, Smaldino & Flexer, 1995; Finitzo-Hieber & Tillman, 1978). In addition to the physical design of the classroom, accurate speech perception may also be decreased as a result of a child experiencing auditory processing difficulties, a temporary CHL or a permanent sensorineural hearing loss (Crandell & Smaldino, 2000).

The physical design, construction of buildings and ventilation methods have been identified as primary contributors to reduced speech recognition ability within the classroom (Crandell & Bess, 1986). New Zealand primary schools were developed during different eras, with many schools undergoing construction and modification for extended periods of time as a consequence of the Christchurch earthquakes throughout 2010 and 2011. Fortunately, standards for building design were updated to include consideration of classroom acoustics in assisting learning and listening (MoE, 2016). The MoE has quantified that schools should meet the recommendations for satisfactory noise levels as specified by the design standards in the Australian and NZ Standards (Australia/NZ Standards, 2016). Consequently, an unoccupied classroom should remain at a noise level of approximately 35dBA. The maximum classroom noise level is recommended to be approximately 45dBA, at which point the noise level tends to exceed the tolerance of the majority. Further to this, the recommended RT is 0.4 to 0.5 seconds. In classrooms supporting students with English as a second language or with learning difficulties, the RT should not exceed 0.4 seconds. The most important factor behind achieving optimal speech recognition is the relationship between the intensity of the signal of interest and the intensity of the background noise at the child's ear (Crandell & Smaldino, 2000).

2.8.2 Reverberation time.

Reverberation time is the time in seconds that is required for a reflected sound component from a source to decrease in level by 60dB after the sound source has ceased (Crandell & Smaldino, 2000). Basically, this is the prolongation or persistence of sound within an enclosure as sound waves reflect off of hard surfaces. Reverberation time is an important acoustic parameter used to determine the acoustic quality of a classroom (Crandell & Smaldino, 2000). The RT gives an indication of the suitability of an environment for speech intelligibility (Lochner & Burger, 1964). Excessive reverberation decreases speech intelligibility due to the spectral energy of the vowels masking subsequent, lower-intensity consonants (Nabelek & Robinson, 1982). In environments which are very reverberant, the reflected sounds can reinforce the original sounds. This means that words may overlap, causing reverberant sound energy to occupy temporal pauses between words (Crandell & Smaldino, 2000). Bradley, Sato and Pickard (2003) emphasised the importance of avoiding excessive reverberant sound, as the reflection pattern of sound was found to be an important determinant in the level of speech intelligibility, rather than the reverberation level itself. The RT is predominantly affected by the volume of the room and the type of surface acoustic absorption strategies utilised (MoE, 2016). Unfortunately, RT and noise have a combined effect. The collaboration between noise and reverberation negatively influences speech perception to a greater extent than the sum of both effects independently (Crandell & Smaldino, 2000). Children under the age of 13 are particularly vulnerable to the combined effect of reverberation and noise in the classroom setting (Nabelek & Nabalek, 1994). The RT recommended by the MoE for MLEs is 0.5 to 0.8 seconds whereas the recommended RT for traditional single-celled classrooms is 0.4 to 0.5 seconds (MoE, 2016).

2.8.3 Background noise.

Noise can be explained as an inessential sound which obstructs what the listener is aiming to hear (Boothroyd, 2004). Several international research studies have concluded that a significant negative relationship exists between high levels of background noise and successful learning with regards to reading ability, cognitive processing and, to a reduced degree, numeracy skills (Bennett 1980; Evans & Maxwell, 1997; Hetu & Truchon-Gagnon, 1990). Irrelevant, non-target speech also has unfavourable repercussions regarding children's ability to perform a variety of literacy tasks (Dockrell & Shield, 2006). Several international research studies have reported that while overall noise levels in open-plan classrooms may sometimes be similar to that of traditional single-celled classrooms, individuals in the open-plan classrooms consistently reported increased distraction as a direct result of noise (Greenland, 2009; Kyzar, 1971). This may be a consequence of intrusive noise arising from neighbouring groups of students in surrounding learning hubs (Greenland, 2009).

Background noise may be separated into two categories; internal noise and external noise (Nelson, Soli, & Seltz, 2002). Internal sources of noise may be generated from equipment, fixtures or occupants such as computers, fluorescent lighting, heating, students and teachers (Nelson, Soli, & Seltz, 2002). External noise may be generated by traffic noise (both road and air), students in nearby classrooms, sirens, construction work and students playing outside (Nelson, Soli, & Seltz, 2002).

Classroom environments are vulnerable to a phenomenon known as the café effect (Whitlock & Dodd, 2006). This is the occurrence of noise breeding further noise inside reverberant environments (Whitlock & Dodd, 2006). Individuals will subconsciously compete with other individuals in order to achieve the optimal SNR, in an effort to increase the likelihood of being understood by those around them (Whitlock & Dodd, 2006). This raises the overall intensity level of noise within an environment. This increase is associated with the café effect, which is often responsible for a lot of the student-generated noise within the classroom. While the overall increase in the intensity of noise inside the room is controlled by the café effect, the rising intensity of each individual's voice is dictated by a separate phenomenon described as the Lombard effect (Lau, 2008). This is the unintentional inclination to raise one's voice when speaking in a noisy environment in order to enhance vocal audibility so that speakers can hear themselves (Whitlock & Dodd, 2006). A select number of people may be able to overcome this effect through conscious control of their vocal volume; however the majority of people do not succeed at this (Whitlock & Dodd, 2006). These two occurrences effectively feed off one another, and it has been suggested the Lombard effect is responsible for the occurrence of the café effect and vice versa (Lubman & Sutherland, 2002).

Children with normal hearing have a reduced capability for extracting useful speech information from distracting background noise compared to adolescents and adults (Johnson, 2000). This is likely due to the mature auditory system being capable of compensating for increased levels of noise, whilst children are more susceptible to being distracted by this (Johnson, 2000). Background noise in the classroom environment is occasionally comprised of meaningful speech. When the meaningful speech was embedded in background noise, the repercussions were extremely detrimental to children's speech recognition ability (Papso & Blood, 1989). Due to neurological immaturity and limited experience, children lack the ability to reliably predict speech phrases from context (Papso & Blood, 1989). This means children's receptive speech and language skills are less efficient as they require optimal acoustic conditions to precisely hear and understand what is being said (Valentine et al., 2002). Children who consistently fail to hear key words and concepts due to suboptimal acoustic conditions are at risk of becoming significantly disadvantaged (Papso & Blood, 1989).

2.8.4 Signal-to-noise ratio (SNR).

The SNR is specified as the relationship between an incoming signal and the level of background noise. Speech perception is easier when the SNR is more favourable and is reduced when the SNR is decreased. This means that the stronger the SNR achieved, the greater benefit a child will receive with regards to their speech understanding (Finitzo-Hieber & Tillman, 1978). The younger a child is, the higher SNR they require, due to the fact that detection of fine acoustic features is achieved before higher levels of auditory processing skills are acquired (Chermak & Musiek, 1997). The dynamic nature of the classroom environment is susceptible to inconsistent SNRs as a consequence of background noise, RTs and variance in the location of the teacher within the classroom (Berg et al., 1993). Several NZ research studies have investigated SNR levels in primary school classrooms around the country (Blake & Busby, 1994; Coddington, 1984). These concluded that the SNR in NZ classrooms range between -5dB and +10dB. These findings are consistent with international research which concluded that SNR in American classrooms tended to exist between -7 and +5dB (Sieben, Crandell, & Gold, 1997).

A SNR of +15dB is reportedly sufficient for all students (regardless of age, hearing sensitivity or native language) to recognise speech (Nelson & Soli, 2000). A NZ study by Blake and Busby in 1994 measured SNRs in classrooms around the Wellington region of NZ. They determined that only 4% of junior school classrooms had a SNR statistically quiet enough for children with normal hearing to receive a clear acoustic signal if they were sitting within 3 metres from their teacher (Blake & Busby, 1994). Based on this research, NZ primary schools need to provide ways to improve the SNR within their classrooms. A potential way to manage this issue is to educate teachers on issues surrounding classroom acoustics, and to provide them with accessible solutions which they could utilise in their classroom environments to help improve the SNR.

2.8.5 Speaker- to- listener distance.

Speech perception is also influenced by the distance from the teacher to the student (Crandell & Smaldino, 2000). As a result of the teacher not remaining in one permanent location in a MLE, the signal reaching the student's ear may oscillate as a consequence of the location of the teacher within the room (Crandell & Smaldino, 2000). If the student's ear is at a distance of greater than three metres from the teacher, the speech signal is vulnerable to distortion due to disturbances within the listening environment (Boothroyd, 2004). The reverberation begins to dominate over the speech signal as the distance between the speaker and the listener increases (Crandell & Smaldino, 2000). The inverse square law (Goldberg & Richburg, 2004) states that the sound level decreases 6dB for every doubling of distance from the sound source (Crandell & Smaldino, 2000). Direct sound pressure follows this law, meaning as the child moves further from the teacher, the more reverberation governs the listening environment (Crandell & Smaldino, 2000). This finding has useful applications within the classroom environment. Specifically, when a student is located within the critical distance to the teacher, the acoustic signal will not be degraded due to reverberation. However, as a child moves beyond the critical distance, the reverberation will significantly reduce their ability for accurate speech perception, especially if this involves degradation of intensity and spectral changes (Crandell & Smaldino, 2000). Speech perception scores are at their peak if the child is right next to the teacher, and begin to degrade as the child moves closer to the point of critical distance (Crandell, 1991; Crandell & Bess, 1986; Leavitt & Flexer, 1991; Peutz, 1971). Beyond this, throughout the remainder of the classroom, speech perception ability tends to remain consistent regardless of the child's positioning beyond the point of critical distance (Crandell, 1991). The implications of this finding are crucial when considering the importance of classroom acoustics. Primarily, it suggests that the ability for speech perception has the most potential for improvement by decreasing the distance between the listener and the speaker within the critical distance of the room (Crandell & Smaldino, 2000). Secondly, it implies that whilst preferential seating may be beneficial, this is not without limitations. In didactic teaching environments, the critical distance for optimal speech perception would only be found at a select few seats which are located close to the teacher. Modern learning environments are designed to be student-centred and flexible, meaning that the critical distance will be different for every student at various points of the day. Therefore, the recommendation of preferential seating may not be enough to ensure that a child is receiving a clear acoustic signal (Crandell & Smaldino, 2000).

Good acoustic properties and materials used within the room can help to maintain a clear acoustic signal for slightly longer than in a poor acoustic environment (Nelson & Soli, 2000). Beyond the point of critical distance, the acoustic signal which reaches the listener has lost many of its spectral components due to multiple, repeated reflections (Nelson & Soli, 2000). Consequently, providing teachers with a method to improve SNRs will be beneficial in assisting children to achieve optimal learning outcomes (Brackett, 1997).

As a consequence of the factors discussed above, the nature of the classroom listening environment is influenced by a myriad of differing aspects. To further investigate which noise sources created the most adverse listening situations for teachers, Valentine at al. (2002)

questioned participants about which noise sources impacted on their classroom listening environment. The responses received back indicated that 71% of teachers felt that noise generated within the classroom environment was bothersome. Of this subset of respondents, 59% reported that most or all of the noise occurring within the classroom environment was student generated. When asked to elaborate upon where the remaining 12% of internal noise originated, the most commonly identified source was computers (Valentine et al., 2002). Given the current shift towards MLEs and the subsequent introduction of digital technology into the everyday classroom, an interesting area for a fresh investigation was identified. This new inquiry could aim to re-assess the noise parameters identified by Valentine et al. (2002), by using teachers working in current MLEs, to assess whether a difference exists when compared to the traditional learning environments investigated by Valentine et al back in 2002. The purpose behind this would be to determine whether there is an increase in reported superfluous noise generated by digital equipment such as iPads and computers in comparison to the responses received by Valentine et al. (2002).

As there is now more attention being paid to the listening difficulties of hearing impaired students (Allen, 1991; Berg, 1993; Cangelossi, 1988; Child & Johnson, 1991; Cooper, 1989; Crandell, 1991; Flexer, 1992), it is an optimal period in which to further investigate whether teachers possess the knowledge and skills to understand the influences that classroom acoustics have on children's learning. This is conducive to the conclusions drawn in the study by Valentine et al. (2002) who aimed to raise awareness of the necessity of good acoustics in NZ classrooms for all children, not solely those with hearing impairments. The findings from Valentine et al. (2002) highlighted the importance of the topic of classroom acoustics being covered in both teacher training and PD programmes. Particular emphasis should be placed upon the incidence and effects of hearing loss in NZ primary schools and the importance of educating teachers regarding the acoustics of their classroom learning environments.

2.9 Teacher engagement with modern learning environments

2.9.1 How teachers have engaged with MLEs in NZ.

Limited studies exist regarding teacher engagement and opinion of MLEs. New Zealand newspapers have conducted interviews with teachers at various MLE schools around the country, resulting in predominately negative feedback being conveyed. In an article by Redmond (2017), an anonymous teacher reported that he had experienced difficulties with management of a classroom with over 50 students. He stated that “people will tell you in private that they find it really hard, but they won’t necessarily back you up in the staffroom. You don’t want to be seen as a naysayer, because you don’t want to be seen as struggling” (Redmond, 2017). Another teacher emphasised “I worry sometimes that the policy has been changed, and people think that teaching practice is going to change overnight. This is actually a cultural change for all of us” (Redmond, 2017).

A concerned teacher who had previous experience teaching in MLEs stated that “it’s not so much the environment being inappropriate, but the lack of professional learning for teachers” (Redmond, 2017). He reported that teachers new to this type of learning environment have a few years of extremely difficult work ahead of them, explaining this as “the first few weeks or months is like trying to teach a different language” (Redmond, 2017). Issues have also been reported regarding increased difficulties managing personal and professional differences during the often stressful transition into collaborative teaching (Redmond, 2017).

Another area of concern often raised is the support provided for schools by the MoE during the transition period. One school principal said he received limited warning that his school was to be among the first in the Canterbury region to undergo transition into a MLE (Redmond, 2017). Upon receiving this news, he immediately took the opportunity to enrol his staff in a custom training programme is assist in this transition. However, he stated schools which underwent this transition at a later period were not provided with the same opportunities for training and PD which would mean their transition was "going to be a challenge" (Redmond, 2017).

The MoE and businesses like CORE Education offer PD programmes when schools request them. The previously-mentioned principal argued that schools should not have to request this service (Redmond, 2017). Teachers have reported significant challenges associated with transitioning into MLEs when professional guidance was not provided (Redmond, 2017). These opinions are reflective of Hattie's (2009) work which emphasised that without investment in teachers, open classrooms are missed opportunities at best. Although flexible learning spaces have the potential to facilitate student-led learning more effectively than traditional classrooms, ultimately it is not the physical space which determines a successful learning environment; it is the teachers and their students (Teaching and Learning International Survey [TALIS], 2009).

2.9.2 How teacher knowledge of classroom acoustics can impact upon successful learning environments.

A South African study by Ramma (2009) investigated the knowledge and attitudes of teachers regarding the impact of classroom acoustics on students' speech perception and learning. This study described how the optimal intervention for poor acoustic classroom design is to employ the services of professionals such as acoustic consultants or educational audiologists. Ideally, this would result in physical modification of the classroom to improve its acoustic properties, including the installation of hearing assistive technologies (American Speech-Language Hearing Association [ASHA], 2005). This standard is not available for all schools due to financial constraints or because of the limited availability of skilled personnel to provide these recommendations (Ramma, 2009). This means that often this issue must be approached in an alternative manner.

An alternative method to providing a change in classroom acoustics would be to work with teachers to provide education around recognising and developing knowledge to compensate for when their classrooms exhibit poor acoustic qualities (Ramma, 2009). It was suggested that educating teachers around simple, yet effective, practices such as shutting doors and windows when facing noise sources or reducing the amount of reflective, hard materials used on the walls could help reduce reverberation (ASHA, 2005).

Ramma (2009) received a total of 59 complete responses to a self-administered questionnaire designed to assess teachers' knowledge of classroom acoustics. An analysis of these responses revealed that none of the respondents reported they felt they had 'very good' knowledge regarding background noise and its subsequent influence upon learning. Seventy-five percent of respondents felt they had an 'average' to 'good' level of knowledge on this same subject. The majority of respondents (94%) reported that they felt teachers required education on classroom acoustics and other factors which have repercussions affecting speech perception in the classroom (Ramma, 2009). Responses were fairly evenly-distributed as to whether this training was best delivered during the period of teacher training (31%) or whether it should be carried out both as part of teacher training and as part of in-service training (29%) (Ramma, 2009). When asked their opinion on the statement "if learners' speech perception is compromised due to poor acoustics in the classroom, then overall academic achievement will be negatively impacted" (Ramma, 2009. p.39), the vast majority of respondents firmly agreed. Contrary to this, when this same group of respondents was asked to rate the impact that excessive background noise, unnecessary reverberation and quiet speaker volume have on speech understanding and learning ability, the majority responded that these factors would have between no impact, to an average amount of impact, on the classroom learning environment.

The discrepancy between these two factors suggests that, as the teachers themselves reported, further education is required to discuss classroom acoustics and their subsequent influence upon learning ability and speech perception. Research by ASHA (2005) found that the negative effect poor acoustic environments can create for classrooms is not usually evident to teachers unless this information is brought to their attention. Prior to recognising this, teachers do not usually treat poor classroom acoustics as barriers to learning (ASHA, 2005). This finding provides support for the notion that teachers should be provided with training regarding classroom acoustics. Opinions among teachers are divided as to whether information regarding classroom acoustics should be delivered during teacher training or as part of further PD programmes (Ramma, 2009). Despite this, it is clear that some form of intervention should be supplied (Eriks-Brophy & Whittingham, 2013; Ramma, 2009). In order to investigate whether this finding is applicable in a domestic context, it is necessary to determine whether NZ primary school teachers are provided with any training with regards to classroom acoustics. Further to this, the optimal method for the distribution of information about classroom acoustics has not been investigated in similar literature and as such, this provided an interesting avenue for investigation within the present pilot study.

While the results generated by Ramma (2009) are reliable, limitations were present which must be considered when determining the validity of extrapolating these results across to a NZ context. The main consideration to be aware of is that the questionnaire was distributed to a small sample of three schools using non-random sampling and participant selection methods. This means that although the researcher made efforts to ensure the selected schools supplied a heterogeneous sample, it is not feasible to assume that the findings will retain accuracy when generalised to a different geographic region. Historically, there have been several studies carried out within NZ regarding the physical acoustic conditions of classrooms (Blake & Busby 1994; Coddington 1984). Despite this, limited NZ-based research exists regarding the knowledge and attitudes of teachers regarding the impact of classroom acoustics on speech perception and learning in primary school classrooms (Valentine et al., 2002).

3.0 Summary

During the latter half of the 20th century, the shift towards globalisation and the subsequent growth of digital technology has prompted international thinking about education and the necessity of shifting towards a new paradigm (Bolstead, 2012). This movement was prompted by an awareness of massive and ongoing social, economic and technological change and the exponentially increasing amount of human knowledge being generated as a consequence (Bolstead, 2012). International thinking began to seriously examine questions regarding the role and purpose of education in a world with an unprecedented degree of complexity, fluidity and uncertainty (Bolstead, 2012).

Investigations highlighted that children do not learn effectively as passive recipients of knowledge (Hattie, 2009). Instead, effective learning requires active engagement in thoughtprovoking tasks. While these concepts are understood by many teachers, the traditional NZ education system was not set up in a way conducive to applying these principles in practice (Bolstad et al., 2012). To enact change, the MoE created a policy to upgrade primary schools to MLEs as part of the 10YPP.

As this shift is recommended by the MoE, it is crucial that teachers are provided with support regarding their changing classroom environments. The nature of the change means that the classroom environments will be larger, class sizes will increase and group work will be regularly facilitated. While research has been carried out to investigate overall noise levels within the different types of classroom environments (Blake & Busby, 1994; Coddington, 1984), limited studies exist regarding teacher engagement towards this shift and their knowledge of classroom acoustics (Valentine et al., 2002). This would be a useful extension upon existing research, as it may provide more support for teachers by identifying where knowledge gaps exist so that targeted support can be provided to increase teachers’ knowledge of classroom acoustics.

Classroom environments with excessive background noise and reverberation have the potential to negatively influence learners’ reading and numeracy skills, in conjunction with detrimentally affecting overall academic performance (Mackenzie, 1999; Maxwell & Evans, 2000). Improving teachers’ knowledge of classroom acoustics will be valuable as improvement in knowledge may assist teachers in having a greater belief about the degree to which they can control the classroom listening environment as opposed to this being dictated by external factors. If the provision of an information package is deemed to be an effective intervention measure for improving knowledge, this would provide a cost-effective, accessible and regulated means of distributing information regarding classroom acoustics to all primary school teachers in NZ.

AIMS AND HYPOTHESES

This thesis aimed to investigate and support teachers' knowledge of classroom acoustics. As such, this pilot study sought to answer the following five research questions:

(1) Do the teachers of MLEs rate their classroom listening environment as poorer than teachers in traditional classrooms?

(2) Which noise sources detrimentally affect the classroom listening environment?

(3) Would the distribution of an information package improve teachers' knowledge about methods which could be implemented to reduce noise levels in the classroom?

(4) Are teachers provided with any training with regards to classroom acoustics?

(5) Is the provision of an information training package an effective option to implement in the future?

Based on the findings of previous research (Valentine et al., 2002; Mealings et al., 2015; Ramma, 2015; Shield, Dockrell & Rigby, 2004) the following hypotheses were proposed for the current study:

For research question (1):

i) Teachers in MLEs will rate their classroom listening environments as poorer than their colleagues teaching in traditional learning environments.

For research question (2):

ii) Teachers will express issues with noise generated inside the classroom, inclusive of noise produced by the students themselves.

For research question (3):

iii) Following the distribution of an information package, teachers' knowledge will improve regarding methods which could be implemented to reduce noise levels in the classroom with regards to:

a) Reducing excess external noise from entering the classroom

b) Importance of eliminating external noise

c) Teachers' knowledge of reverberation

d) Teachers' knowledge regarding whether acoustics have a direct effect on students' learning ability.

For research question (4):

iv) The majority of teachers would have received training with regards to classroom acoustics.

For research question (5):

v) The provision of an information package will be an effective option which could be implemented in the future.

METHODS

4.0 Ethical approval

Approval to conduct this study was obtained from the University of Canterbury Educational Research Human Ethics Committee (see Appendix A). The procedures used to conduct this study were carried out in accordance with the approval. All participants received study information sheets and had electronically signed consent forms prior to their involvement in this study.

4.1 Study design

A descriptive cross-sectional survey research design (Bowling, 2014) was developed to collect data in order to answer the research questions.

4.2 Participants

The inclusion criteria for participants were to be a current year one primary school teacher or to have taught year one students in a NZ primary school classroom within the past five years. The restriction to year one teachers was decided upon due to the research conducted by White-Schwoch et al. (2015) which emphasised that younger children (aged up to five years old) had a weaker auditory-neurophysiological response to consonant-vowel syllables in the presence of background noise as opposed to in quiet conditions. Consequently, the younger the child the greater the effect of background noise on auditory perception of consonants. Whilst older children are still influenced by this phenomenon, it was thought that for the purposes of this small pilot study, it would be of greater importance to assess the knowledge of teachers of children at, and around the age of, five. The second inclusion criteria was that participants had to be capable of finalising all tasks required of them, which included processing the material summarised in the information pack and completing two surveys. To confirm this, participants were asked to electronically-sign an information sheet and consent form prior to commencing their participation in the study. A priori G*Power analysis was used to determine the adequate sample size for this study. When calculated using an effect size of 0.8, a total sample size of 42 participants was recommended (n=21 in each group). Due to monetary constraints regarding the allocation of incentives, and the fact that the study by Mealings et al. (2015) used 18 participants, it was decided that a total of 20 teachers could be used for this pilot study (n = 10 in each group), utilising an overall effect size of 1.2.

4.3 Sampling

The current NZ school directory as of July 3rd 2017 was obtained from the Government website 'Education Counts' (http://www.educationcounts.govt.nz/home). Opportunity sampling was selected as the method to be utilised in recruiting participants. Subsequently, the downloaded current NZ school directory was filtered using Microsoft Excel 2010 to distinguish primary schools from secondary schools. Following this, the entire cohort of secondary schools was removed from the spread sheet and thus a list of NZ primary schools who has previously agreed to be contacted for research purposes remained. These schools were subsequently filtered so that only those within the Christchurch and wider Canterbury region remained. A token incentive of $30 per participant was provided as acknowledgement of the time they would contribute to the study. To ensure schools had an equal probability of being invited to partake in this research, each eligible school was allocated a digit and a random number generator was applied to produce a list of twenty numbers at a time. Following this, an email was sent to a group of 20 randomly selected school principals, requesting year one teachers as participants. This procedure was repeated until a total of 20 participants were obtained.

4.4 Pilot study

The survey was piloted with six participants who were current NZ primary school teachers. The sample cohort was selected from this profession to ensure reliability and content validity with the intended study sample (Maxwell & Satake, 2006). A number of adjustments were made to questions based on feedback from the pilot survey. For example, with regards to the multi-choice question 19, a selection was added for 'don't know' as opposed to solely a pre-determined set of options. Other feedback opted for requests around the ability to elaborate upon the answers to multi-choice questions where pilot participants felt that their answer could be further explained. Another problem identified was with question 18; "approximately what percentage of time do you spend in the classroom teaching in each of these styles?" This question utilised a Likert scale design and for an unknown reason, the sliding scale was unable to be correctly shifted to the desired response. To resolve this issue, this question was redesigned with increments of 10 as opposed to 20 and resubmitted into the survey design. Finally, a title was added at the beginning of the survey and a progress bar was installed to provide participants with a visual scale of their advancement towards completing the survey. Whilst statistically significant benefits regarding the addition of a progress bar have not been determined (Villar, Callegaro, & Yang, 2013), there is also no evidence to suggest this addition to be a detriment to the success of the survey. However, the additional benefits of using a progress indicator such as improving participant satisfaction with the survey experience have been reported (Conrad, Couper, Tourangeau, & Peytchevet, 2010; Matzat, Snijders, & van der Horst, 2009), which provide sufficient rationale to support the inclusion of this tool in the study.

4.5 Design of survey

The survey used was specifically designed for the purposes of this study based upon surveys utilised in similar research (Ramma, 2009; Valentine et al., 2002). The survey used by Ramma (2009) included questions surrounding whether continuing education had been provided to teachers regarding their knowledge of speech perception and classroom acoustics. This survey was designed purposely for use within that study, however no information as to whether it had been peer reviewed was made available. Despite this, it was piloted among 10 similar participants to establish reliability and content validity (Maxwell & Satake, 2006). A selection of the rationale underlying the development of the survey utilised by Ramma (2009) was combined with a subset of the information used by Valentine et al. (2002). Valentine et al. (2002) utilised a survey which was initially developed with the assistance of three architectural acoustics students from the University of Auckland and piloted with teachers at an Auckland primary school. This survey investigated teachers' opinions of noise sources, teaching style and room characteristics in relation to the acoustics of the classroom. Consequently, an amalgamation of information from the two surveys was combined and reworked into a new survey in order to better serve the aims of this pilot project.

The pre-survey consisted of 5 sections with a total of 24 questions, while the post survey had a total of 22 questions. Example questions included:

i) How do you rate your classroom listening environment?

ii) Have you heard of the term reverberation?

iii) What proportion of noise inside the classroom is student generated?

Full versions of both the pre-survey and the post-survey can be found in Appendix C.

4.6 Rationale for information package

Self-education resources are often distributed in the form of pamphlets, brochures or posters. Although these mediums are a common resource across self-education practices, there has been limited systematic research with respect to the design effectiveness of these mediums in increasing overall comprehension levels (Whittingham, Ruiter, Castermans, Huiberts, & Kok, 2007). As such, international research by Young, Wong and Cheung (2013) aimed to investigate the effectiveness of educational posters for improving the knowledge level of primary and secondary school teachers regarding emergency management of dental trauma. Teachers' underlying knowledge regarding dental trauma was obtained through a questionnaire in order to determine their baseline understanding. Following this, posters containing information regarding dental trauma management were displayed in schools with the intervention groups for 2 weeks; the control group received no posters. At the conclusion of these 2 weeks, a follow up questionnaire was circulated. Young, Wong and Cheung (2013) found that those in the intervention group showed statistically significant improvements in their knowledge of dental trauma (p <0.0001), indicating that educational posters significantly improved knowledge on this topic for the primary and secondary school teachers who participated in the study.

Despite the research by Young, Wong and Cheung (2013) providing an evidence base for the use of educational posters, limited research exists regarding the use of online information packages, as was utilised in the present pilot study. International research by Gunn and Pitt

(2003) investigated the usefulness of providing students with electronic information packages. Effectiveness of this method was assessed via questionnaires, patterns of use (monitored using the computer system) and the marks from the end of module examination. The results determined that participants valued the electronic information package as it provided a means to reinforce learning, and a strong preference for the ability to download the information package for personal use was expressed by the participants. Despite this however, feedback was obtained which indicated that participants would not want to have the majority of their lecture time replaced by electronic information packages. Gunn and Pitt (2003) concluded that while information packages are an effective means of supporting learning, other forms of contact time with the learner must be incorporated to facilitate maximum retention of information, such as face-to-face programmes.

The findings by Gunn and Pitt (2003) provided supporting rationale for further investigations into the effectiveness of an electronic information package as a means of distributing information. As it was necessary to provide the resource online due to variance in geographical location within the wider Canterbury region, it was decided against utilising a poster design as investigated by Young, Wong and Cheung (2013). Instead, it was decided to extend on the findings of Gunn and Pitt (2003), and an electronic information package in the form of an infographic was utilised in this pilot study. As recommended by Gunn and Pitt (2003), this resource had the potential to be downloaded onto each participant's computer to be stored for personal use.

4.7 Design of information pack

Information graphics, or infographics, are a method used to visually represent information, data or knowledge (Cairo, 2006). Infographics offer an effective means of providing large quantities of information concisely through the use of visually appealing elements which attract attention and facilitate retention (Cairo, 2006). As such, it was decided that using an infographic to design the information package would be a powerful way of communicating the required information as opposed to solely using written text. Cairo (2006) states that "infographics are fundamental tools in education, and even more so in present days where we have them in digital format and take advantage that multimedia resources offer" (Cairo, 2006. p. 15). The idea that infographics are a valuable teaching resource has become increasingly popular, as they provide an effective means to summarise information in order to improve learning (Cairo, 2006). In addition to this, an infographic information package held the additional appeal that it could be created and distributed online via email to participants. This meant that all participants were able to receive the intervention electronically and in a timely manner. The tools used to create the infographic were obtained through an online source (www.piktochart.com).

The majority of individuals form their opinion regarding the appeal of an infographic within 500 milliseconds of first being introduced to the material (Harrison, Reinecke, & Chang, 2015). The most important factor for an individual when forming their initial opinion of the infographic is how colourful the material is, followed by its degree of visual complexity (Harrison et al., 2015). In order to maximise the likelihood that the consumer will form a positive opinion of the infographic, Harrison et al. (2015) emphasised that it is ideal to choose a medium to high degree of colourfulness. This can be enhanced by increasing the saturation and contrast between colours. Additionally, a low to medium level of complexity is ideal, meaning information should be clearly presented within a limited number of text and image areas.

Further to this, Harrison et al. (2015) investigated the relationship between preference for colour and complexity with regards to age, gender and education level. It was concluded that females prefer more colourful, yet less complex infographics than males. Additionally, it was concluded that preference for more simple infographics increases slightly with age and education level (Harrison et al., 2015).

Based upon the demographic information of participants in this study, the design that would hold the highest appeal for the majority of participants would be bright, colourful and of reasonably low complexity. As such, it was decided that blue, yellow and green would provide ample colour and contrast against a predominantly white background. This was the chosen background colour because it was necessary to maintain an ample degree of white space throughout the document, especially as the layout of images and texts varied based upon the presented information.

4.7.1 Information package content.

The majority of the information presented in the infographic was obtained from the DQLS document authorised by the MoE (MoE, 2016). The purpose of this document is to provide technical requirements and guidance for the acoustic design of school buildings in NZ. It contains useful information about what factors influence classroom acoustics and potential methods which could be implemented to solve these issues. Where required, additional information was researched and included in the infographic. This information was referenced at the conclusion of the first page of the information package in the event that participants wanted to utilise any of these resources further. Participants were provided with the information package in PDF via email. This email provided them with instructions to download and read the information package at their leisure throughout the course of the week prior to the distribution of the post-survey.

4.8 Data Collection Procedure

Communication with participants during the study was primarily achieved through electronic mail. The initial recruitment email provided participants with an information sheet containing detailed, comprehensive information about the purpose of the study and the requirements for individual participants. An electronic consent form was included with this information sheet, which participants were asked return via email giving their consent to take part in the study.

The data collection process was three-fold and persisted over the duration of five weeks. After consent was obtained, the first survey was sent to participants via an anonymous link. A two-week time frame was allocated for the completion of this task. After the completion of the initial survey, participants were sent the information package (see Appendix D) in PDF format as an email attachment. This email contained instructions to read and consider the material provided in the information package relative to their classroom and the acoustics of their everyday teaching environment. Participants were given one week to read through this resource. One week after this document was distributed, a third and final email was sent with a different anonymous link which contained the post-survey. A Microsoft Excel spreadsheet was used to track what stage each individual teacher was up to in their participation in the study to ensure that surveys and information packages were distributed at the appropriate times. It was requested of participants that they endeavour to complete the post-survey within two weeks of its distribution.

After a complete set of responses were successfully received back from each participant, they were sent a $30 petrol voucher to their school address.

4.9 Data analysis

The majority of this data was analysed using descriptive statistics in Microsoft Excel 2010. Results from both the pre-survey and the post-survey were exported as raw data into two separate Microsoft Excel spreadsheets. Following this, the pre-survey responses from each individual were matched to their post-survey responses and collated into a third spreadsheet for analysis. To analyse the variables, each response was assigned a number. Following this, the pre-survey and post-survey scores were compared numerically and analysed to measure changes in response from each individual. For the non-continuous variables, descriptive statistics were used to obtain frequencies. Pearson chi-square tests and repeated measures Analysis of Variance (ANOVA) tests were run using the International Business Machines (IBM) Statistical Package for the Social Sciences version 24 (IBM, 2016), to determine the statistical significance of measured outcomes.

The survey questions were based on previous research by Valentine et al. (2002) and Ramma (2015) and modified for the purposes of this research. The pre-survey (n=24) contained two more questions than the post-survey (n = 22) to account for the collection of demographic information. This will be commented on further in the limitations section. However, throughout the course of the study, only a subset of the total number of questions was identified as directly relevant to answering the research questions of this pilot study. As such, these will form the basis of the following results section however qualitative data gathered from a subset of the remaining questions will also be discussed.

RESULTS

This section reports both qualitative and quantitative responses from the pre-survey and the post-survey. This includes contrasting the changes in responses between these two measures. Additionally, responses from teachers in MLEs will be compared against the responses received from teachers working in traditional learning environments (i.e., single teacher classrooms).

5.0 Demographic information

5.0.1 Experience with hearing loss.

A total of 20 participants agreed to participate in this study. Twelve (60%) had either previously taught a child with hearing loss or were currently teaching a child with hearing loss and the remaining eight (40%) had no experience teaching a child with hearing loss. A Pearson chi-squared test was run to determine whether there was a significant association between teachers' experience with teaching a child with hearing loss and the type of classroom environment they taught in (MLE versus traditional). Cross-tabulation showed no significant difference in the distribution between teachers who had taught a child with hearing loss and the type of classroom environment they taught in χ 2 (1, N = 20) = 3.33, p = .068.

5.0.2 Gender.

The demographic information gathered from emails received from participants in this study revealed 19 female teachers and 1 male teacher. All 20 participants had completed education at a tertiary level. The age of the participants remained undisclosed.

5.0.3 Teaching environment.

Ten (50%) teachers were currently working in traditional learning environments. Six (30%) teachers were working in primary schools which were in the process of transitioning into MLEs. An additional four (20%) teachers were working in primary schools with already established MLEs. For the purposes of this study, the six teachers who indicated they are already actively transitioning into MLEs were included as currently working in a MLE for the analysis of the data. Consequently, 50% of participants were working in traditional learning environments and 50% were working in MLEs or under MLE conditions.

Prior to the commencement of this study, all twenty participants indicated on their pre-survey that they had never heard of the MoE Acoustic Guidelines which were published in September 2016 (MoE, 2016).

5.1 Classroom listening environments

Research question one:

(1) Do the teachers of MLEs rate their classroom listening environment poorer than teachers in traditional classrooms?

Participants were asked to rate their classroom listening environment on a five-point Likert scale ranging from 'very good' to 'very poor'. In order to analyse the data, their responses were converted numerically and coded as follows; 5 = 'very good', 4 = 'good', 3 = 'acceptable', 2 = 'poor' and 1 = 'very poor'.

Figure 2 below shows teachers' opinions of their classroom listening environment in the pre-survey compared to the post-survey. Further analyses of these responses are discussed in the following section.

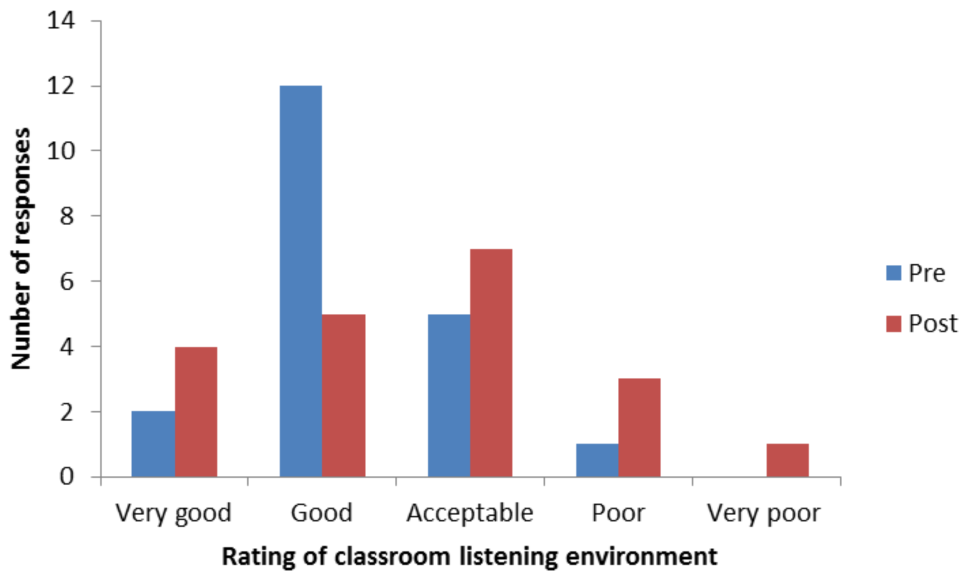

Figure 2: Teachers' opinions of their classroom listening environment in the pre-survey and the post-survey.

Data were checked for significance, skewness, kurtosis and outliers. As no breaches in parametric assumption and no significant bias was found, parametric tests were used to analyse the responses. A repeated measures ANOVA showed no significant change in teachers' rating of their classroom listening environment between the pre-survey and the post-survey; $F(1, 18) = .621$, $p = .441$, $\eta^2 = .03$. Similarly, there was no significant interaction between the rating of the classroom listening environment and classroom type (MLE vs traditional); $F(1, 18) = .00$, $p > .99$, $\eta^2 < .00$, indicating the type of classroom environment had no effect on the pre-survey or post-survey scores. Means and standard deviations for these data are reported in Table 2 below.

Table 2: Means and standard deviations of the pre-survey and post-survey scores regarding teachers' opinions of the classroom listening environment.

Survey	*Classroom*	*Mean*	*Std. Deviation*
Pre-survey	MLE	3.60	.70
	Traditional	3.90	.74
	Total	3.75	.72
Post-survey	MLE	3.40	1.08
	Traditional	3.70	.95
	Total	3.55	.99

Table 2 depicts that in the pre-survey, participants teaching in traditional learning environments reported slightly higher (3.90) overall satisfaction with their classroom listening environment than those teaching in MLEs (3.60). This trend continued after the distribution of the information pack, as the results of the post-survey also revealed teachers in traditional learning environments reported slightly higher (3.70) overall satisfaction with their classroom listening environments than their MLE colleagues (3.40). It should be noted that on average the overall level of satisfaction decreased slightly (-0.20) across both classroom conditions in the post-survey when compared to the pre-survey, though not at a level indicative of statistical significance.

Individual responses between the pre-survey ratings and post-survey ratings were also measured, and are displayed in Table 3 below. Numerical changes in responses were measured for each participant. Figure 3 below depicts the meanings behind each different numerical change. The changes for each participant are displayed in Table 3 below.

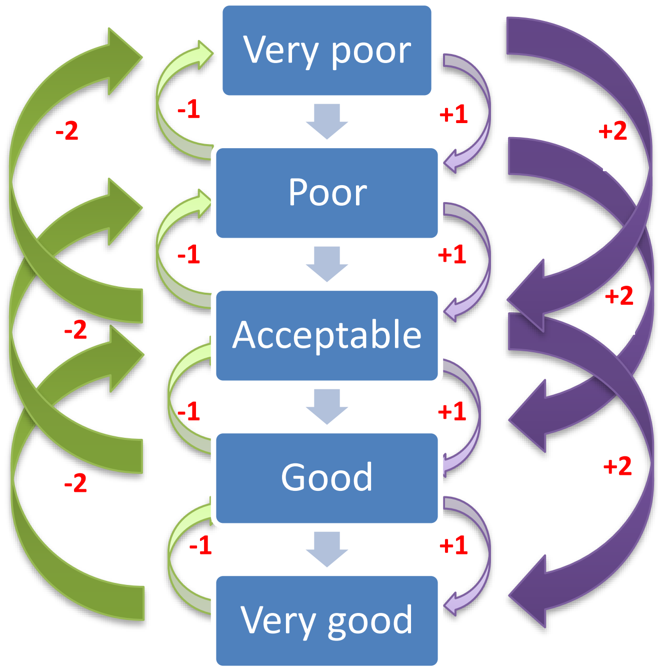

Figure 3: Meanings behind the different numerical changes discussed further in Table 3 below.

Cross-tabulation showed no significant difference in distribution regarding changes in responses between the pre-survey and post-survey scores, χ 2 (3, N = 20) = 2.49, *p* = .56. This indicates that the type of classroom environment (MLE versus traditional) had no effect on different ratings in the pre-survey compared to the post-survey. As such, the null hypothesis cannot be rejected as teachers in MLEs did not rate their classroom listening environments as poorer than their colleagues teaching in traditional learning environments.

Table 3: Individual changes in the post-survey score compared to the pre-survey score regarding teachers' opinions of the classroom listening environment.

		-2.00	*-1.00*	*.00*	*1.00*	*Total*
Classroom	MLE	2.00	3.00	2.00	3.00	10.00
	Traditional	2.00	1.00	5.00	2.00	10.00
Total		4.00	4.00	7.00	5.00	20.00

5.2 Influence of noise sources

Research question two:

(2) Which noise sources detrimentally affect the classroom listening environment?

The hypothesis to be investigated was that teachers would express issues with noise generated inside the classroom, inclusive of noise produced by the students themselves. The results of the pre-survey showed that at a group level, 65% of all participants in the pre-survey indicated that they experienced difficulty with noise created inside the classroom (MLE = 70%, traditional = 60%). In the post-survey, 85% of participants indicated they experienced issues with this problem (MLE = 90%, traditional = 80%). Based on this information, the null hypothesis was rejected as teachers' did express issues with noise generated inside the classroom, inclusive of noise produced by the students themselves.

Change in individual responses between the pre and post survey were measured. A 'no' response was assigned a rating of 1, while 'yes' was assigned a rating of 2. A negative score indicates a participant who selected 'yes' in the pre-survey now selected 'no' in the post-survey. A neutral score indicates the same response was selected across both surveys. A positive score indicates a 'no' in the pre-survey had changed to a 'yes' in the post-survey. Results are shown in Table 4 below.

Cross-tabulation showed no significant difference in the distribution of changes in responses between the pre-survey and post-survey for this question $\chi 2$ (1, N = 20) = .00, $p >$ .99, indicating that the type of classroom environment (MLE vs traditional) had no effect on whether a teacher indicated they experienced issues with noise created inside the classroom between the pre-survey and the post-survey.

Table 4: Individual changes in the post-survey score compared to the pre-survey score regarding whether teachers expressed issues with noise generated inside the classroom.

		-1.00	*.00*	*+1.00*	*Total*
Classroom	MLE	2.00	8.00	.00	10.00
	Traditional	2.00	8.00	.00	10.00
Total		4.00	16.00	.00	20.00

To elaborate on the above question, participants were asked what proportion of noise inside the classroom was student-generated. A four-point Likert scale was used to assess this, with responses ranging from 'all' through to 'none'. In order to analyse this data, responses were converted numerically and coded as follows; 4 = 'all', 3 = 'most', 2 = 'some', 1 = 'none'.

Data were checked for significant skewness, kurtosis and outliers. There were no breaches in parametric assumption and because no significant bias was found, parametric tests were used to analyse the responses to this question. A repeated measures ANOVA showed no significant change in rating between the pre-survey and the post-survey F (1, 18) = .953, $p =$

.342, $\eta^2 = .05$. Additionally, there was no significant interaction between the rating assigned and the classroom type, $F(1, 18) = .106$, $p = .749$, $\eta^2 = .006$, indicating the type of classroom environment (MLE versus traditional) had no effect on the pre-survey or post-survey ratings. Means and standard deviations are reported in Table 5 below.

Table 5: Means and standard deviations regarding whether teachers expressed issues with noise generated inside the classroom, inclusive of noise produced by the students themselves.

	Classroom	*Mean*	*Std. Deviation*
Pre-survey	MLE	3.00	.47
	Traditional	3.10	.57
	Total	3.05	.51
Post-survey	MLE	2.90	.32
	Traditional	2.90	.74
	Total	2.90	.55

Table 5 above shows that participants who taught in traditional learning environments were more of the opinion that students generated 'most' of the classroom noise (3.10) compared to their MLE colleagues (3.00). The post-survey scores reflected a slight decrease in teachers' perceptions regarding what proportion of noise inside the classroom was student generated. Results from the post-survey indicate that teachers in both traditional classrooms (2.90) and MLEs (2.90) alike now both agreed that 'some' of the noise inside the classroom is student generated.

Assessments were made regarding individual changes in opinion between teachers' thoughts regarding how much of the noise in the classroom environment was generated by students. Numerical changes in responses were measured for each participant. Figure 4 below depicts the meanings behind each different numerical change. The changes for each participant are displayed in Table 6 below.

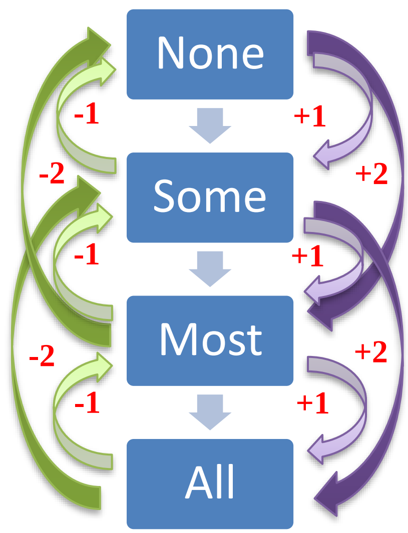

Figure 4: Meanings behind the different numerical changes (discussed further in Table 6 below).

For those participants who did show change, two participants shifted one negative point, suggesting that their viewpoint shifted towards less classroom noise being generated by students. Fourteen participants selected the same response in both the pre-survey and the post-survey. Three participants showed a one point positive change indicating that in the post-survey, they attributed more of the classroom noise as being produced by students. One participant shifted two points in the positive direction.

Table 6: Individual changes in the post-survey score compared to the pre-survey score regarding how much of the noise in the classroom environment was generated by students.

		-1.00	*.00*	*1.00*	*2.00*	*Total*
Classroom	MLE	1.00	7.00	2.00	.00	10.00
	Traditional	1.00	7.00	1.00	1.00	10.00
Total		2.00	14.00	3.00	1.00	20.00

Cross-tabulation showed no significant difference in the distribution of changes in responses between the pre-survey and post-survey for this question $\chi 2$ (3, N = 20) = 1.33, $p >$ .99, indicating that the type of classroom environment (MLE versus traditional) had no effect on the change in the rating of which proportion of noise in the classroom was generated by students between the pre-survey and the post-survey.

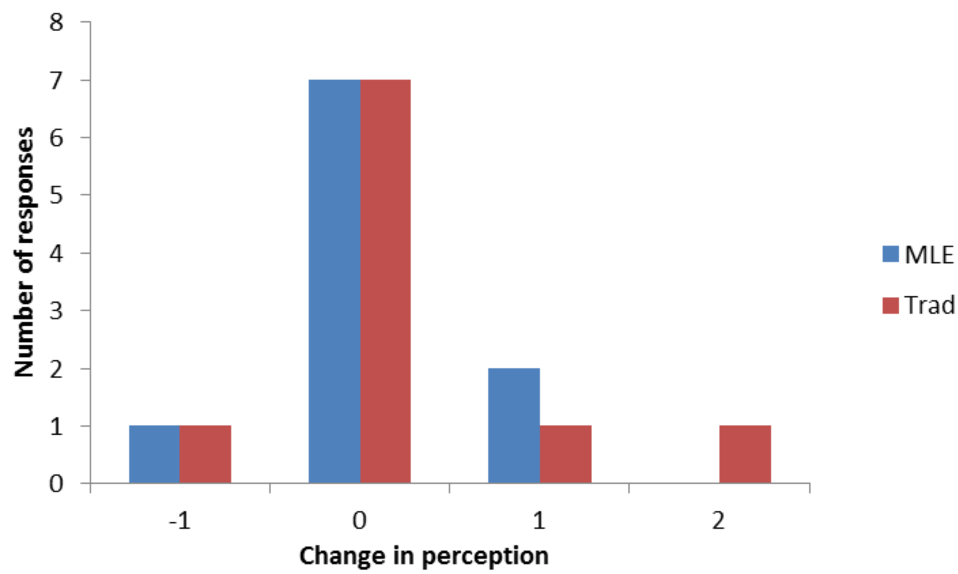

Figure 5: The number of points that individuals shifted in rating regarding the perception of what proportion of classroom noise is generated by students between the pre-survey and the post-survey.

5.2.1 Additional sources of noise.

Further to this, teachers were asked to identify from a pre-determined list of six responses the sources of noise which were generated within the classroom. Following the distribution of the information package, eight participants (40%) selected more responses than they did in the pre-survey. Nine (45%) participants selected the same number of sources in both the pre-survey and post-survey. The remaining three (15%) participants selected fewer noise sources in the post-survey than in the pre-survey.

The overall trend regarding which of the selected sources showed the greatest change in response was investigated. This is represented in Figure 6 below. The qualitative trend for equipment, air conditioning and heaters was for responses to increase following the distribution of the information package. The last three categories tended to decrease, with lights, fans and the 'other' category all receiving fewer responses in the post-survey than the pre-survey.

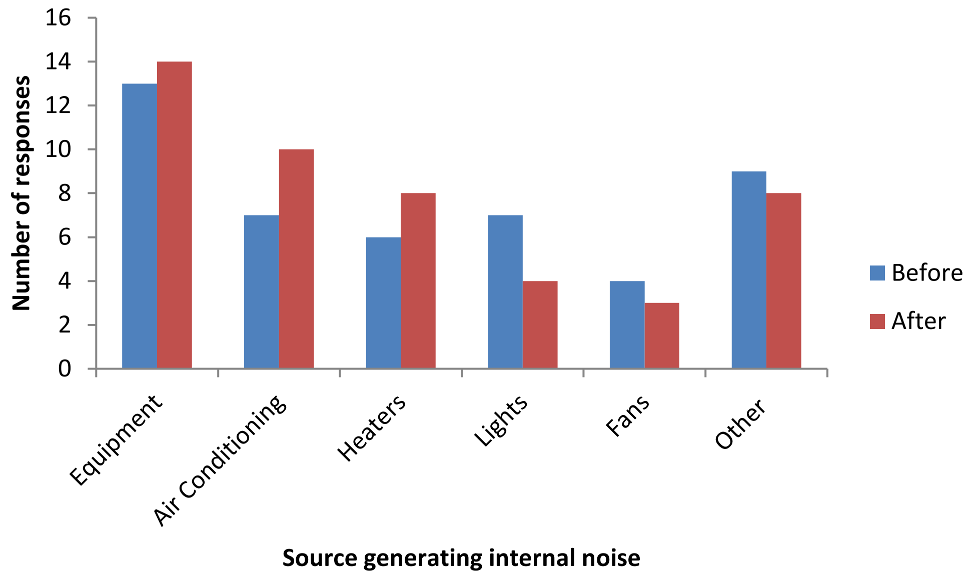

Figure 6: Number of responses received regarding different sources generating internal noise.

The number of responses received for each respective 'other' category is elaborated upon in Figure 7 below. Three participants (15%) identified iPads and/or computers as sources generating internal noise in both the pre-survey. This increased slightly to four participants (20%) and the post-survey. Other commonalities between both measures were reports of noise generated by people, with three (15%) participants identifying this in the pre-survey and one participant (5%) suggesting this in the post-survey. Finally, plumbing noise was also identified between both measures, with two participants (10%) reporting this as problematic in the pre-survey and one participant (5%) reporting this in the post-survey. In the pre-survey, one participant (5%) reported their classroom heat-pump was in need of a part replacement. The post-survey had an additional two reported categories. One participant (5%) reported problems caused by noise generated by the fish tank and one participant (5%) from the classroom intercom.

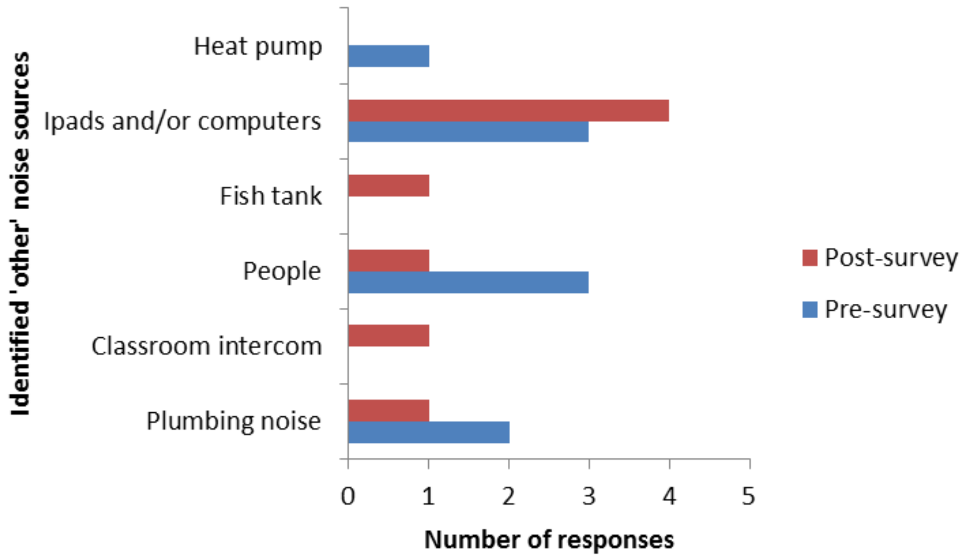

Figure 7: Number of responses received regarding 'other' sources of internally generated noise.

5.2.2 External noise.

Participants were asked to indicate whether they experienced issues with outside noise entering the classroom, inclusive of noise from adjacent rooms. These responses are shown in Figure 8 below. Those who experienced issues with noise are depicted in blue, while those who did not are depicted in red.

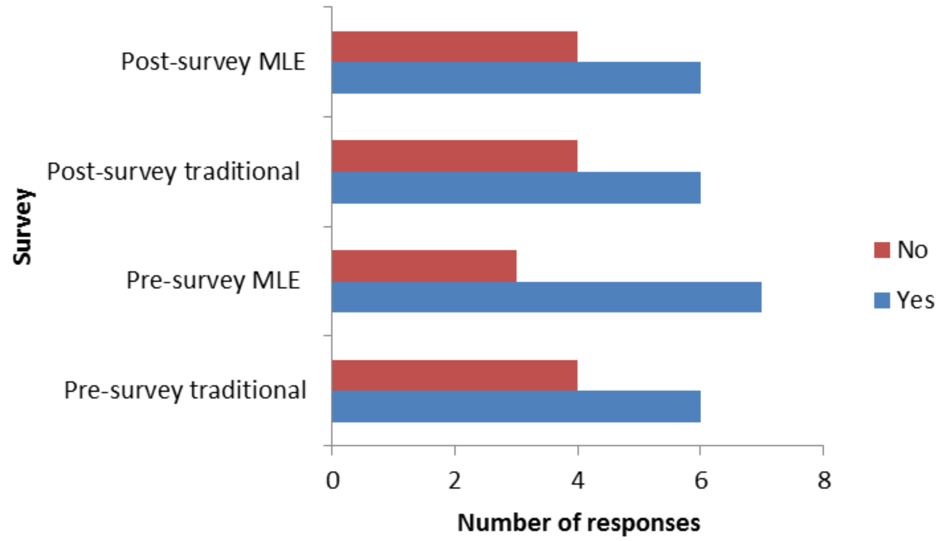

Figure 8: Number of people who reported issues with noise depending on their classroom type in the pre-survey compared to the post-survey.

In the pre-survey, six participants (60%) teaching in traditional learning environments expressed they experienced issues with this. Of those teaching in MLEs, seven participants (70%) indicated they experienced issues regarding this same construct. In the post-survey, the group score for those in traditional learning environments remained a stable reflection of that of the pre-survey, as six participants (60%) reported they experienced issues with outside noise entering the classroom. The number of reported issues in MLEs decreased by one respondent, with the overall percentage of participants now reporting problems with this issue also sitting at 60%.

Individual responses between the pre-survey ratings and post-survey ratings were also measured. Cross-tabulation showed no significant difference in the distribution of changes in responses between the pre-survey and post-survey for this question χ 2 (2, N = 20) = .406, p =

.819, indicating that the type of classroom environment (MLE versus traditional) had no effect on the change in ratings across the two different surveys. This is shown in Table 7 below.

Table 7: Change in viewpoint between the pre and post-surveys regarding issues with external noise entering the classroom, with consideration to the type of classroom environment.

Classroom	*Negative change*	*No change*	*Positive change*	*Total*
MLE	2.00	7.00	1.00	10.00
Traditional	1.00	8.00	1.00	10.00
Total	3.00	15.00	2.00	20.00

5.3 Distribution of the information package

Research question three:

(3) Did the distribution of an information package improve teachers' knowledge about methods which could be implemented to reduce noise levels in the classroom?

Hypothesis 1:

Following the distribution of an information package, teachers' knowledge will improve regarding methods which could be implemented to reduce noise levels in the classroom with regards to:

a) Reducing excess external noise from entering the classroom

As a group, nine teachers in the pre-survey were unsure about methods they could implement to help reduce or eliminate excess external noise from entering the classroom, whilst the remaining 11 participants were able to elaborate upon some ideas for this. In the post-survey, the number of teachers who were able to elaborate upon ideas increased to 15, while the remaining five remained uncertain about methods they could implement to assist reducing excess external noise from entering the classroom. This is shown in Figure 9 below.

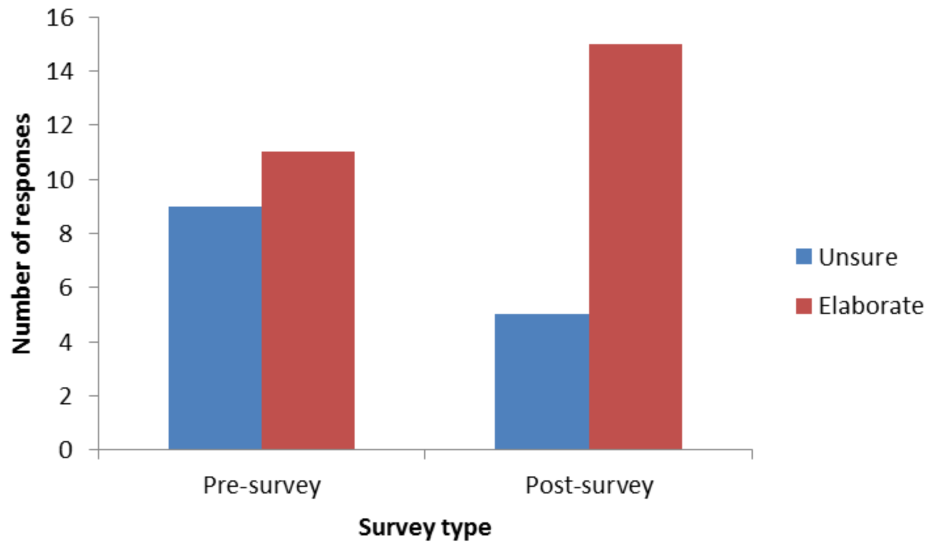

Figure 9: Number of teachers' able to elaborate on ideas on what could be done to eliminate external noise compared to those who could not across both survey conditions.

Individual responses between the pre-survey ratings and post-survey ratings were measured. Cross-tabulation showed no significant difference in the distribution of changes in responses between the pre-survey and post-survey for this question $\chi 2$ (2, N = 20) = 2.33, p = .311, indicating that the type of classroom environment (MLE versus traditional) had no effect teachers' opinions about what could be done to eliminate excess noises from outside the classroom.

Table 8: Change in viewpoint between the pre and post-surveys regarding teachers' opinions about what could be done to eliminate excess noises from outside the classroom.

Classroom	*Negative change*	*No change*	*Positive change*	*Total*
MLE	2.00	5.00	3.00	10.00
Traditional	.00	7.00	3.00	10.00
Total	2.00	12.00	6.00	20.00

As such, we cannot reject the null hypothesis and it can be concluded that the distribution of an information package did not significantly improve teachers' knowledge about methods which could be implemented to reduce excess internal noise from entering the classroom.

Hypothesis 2:

Following the distribution of an information package, teachers' knowledge will improve regarding methods which could be implemented to reduce noise levels in the classroom with regards to:

b) Importance of eliminating or reducing external noise

Participants were asked how important they thought it was to reduce or eliminate sources of outside noise from infiltrating their classrooms. A five-point Likert scale was used which ranged from 'extremely important' to 'not at all important'. In order to analyse the data, participant responses were converted numerically and coded as follows; 5 = 'extremely important', 4 = 'very important', 3 = 'moderately important', 2 = 'slightly important' and 1 = 'not at all important'.

Data were checked for significant skewness, kurtosis and outliers. There were no violations of parametric assumption, and because no significant bias was found, parametric tests were used to analyse the responses to this question. A repeated measures ANOVA showed a significant change in the importance of eliminating or reducing external noise for students between the pre-survey and the post-survey; $F(1, 18) = 13.23$, $p = .002$, $\eta^2 = .42$. Despite this, there was no significant interaction between the importance of eliminating or reducing external noise for students and classroom type; $F(1, 18) = 2.88$, $p = .107$, $\eta^2 = .14$, indicating the type of classroom environment had no effect on the pre-survey or post-survey scores. Means and standard deviations are reported in Table 9 below.

Table 9: Means and standard deviations for pre-survey and post-survey scores regarding reducing or eliminate sources of outside noise from infiltrating into classrooms.

	Classroom	*Mean*	*Std. Deviation*
Pre-survey	MLE	3.40	1.36
	Traditional	3.80	.92
Post-survey	MLE	4.50	.53
	Traditional	4.20	1.14

Individual responses between the pre-survey ratings and post-survey ratings were measured. Numerical changes in responses were measured for each participant. Figure 10 below depicts the meanings behind each different numerical change.

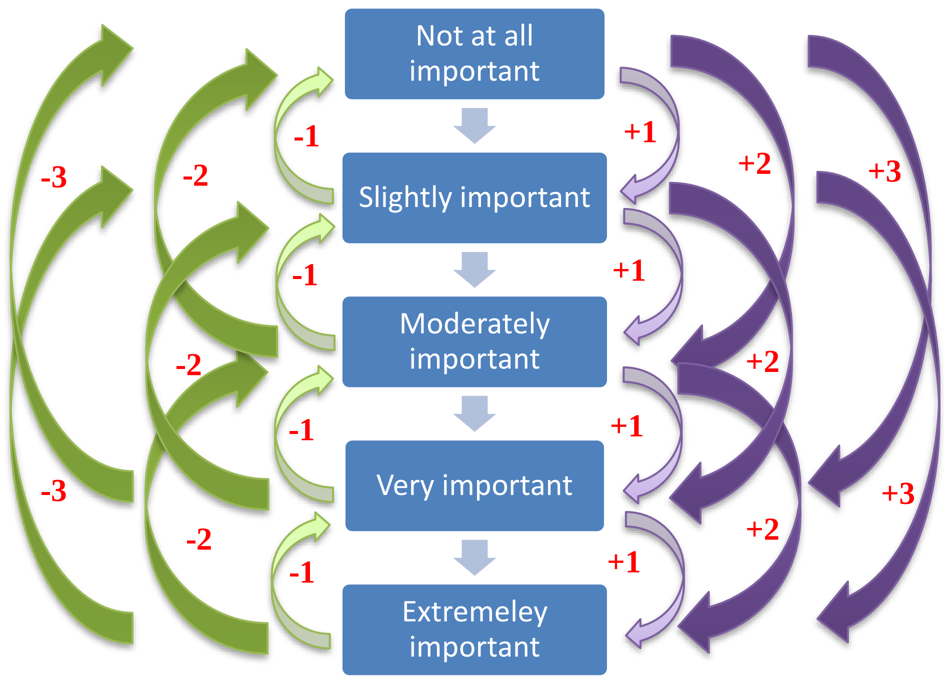

Figure 10: Meanings behind the different numerical changes (discussed further in Figure 11 below).

Cross-tabulation showed no significant difference in the distribution of changes in responses between the pre-survey and post-survey for this question χ 2 (4, N = 20) = 6.29, p = .179, indicating that the type of classroom environment (MLE vs traditional) had no effect teachers' opinions about the importance of eliminating or reducing external noises for students. These changes are shown in Figure 11 below. In the post-survey, of the teachers working in MLEs, six (60%) participants showed a positive change, meaning their opinion shifted more closely towards the 'extremely important' condition. The remaining four (40%) participants remained neutral in their selections meaning they provided the same response in the post-survey as they did in the pre-survey. Although not statistically significant, the changes in responses from individual teachers in traditional learning environments also reflected a positive trend with five (50%) participants showing a positive change. Four (40%) remained neutral in their selections, a number which was consistent with those in the MLE condition. One (10%) participant showed a negative change, meaning their perception of the importance of reducing or eliminating external noise sources decreased following the distribution of the information package.

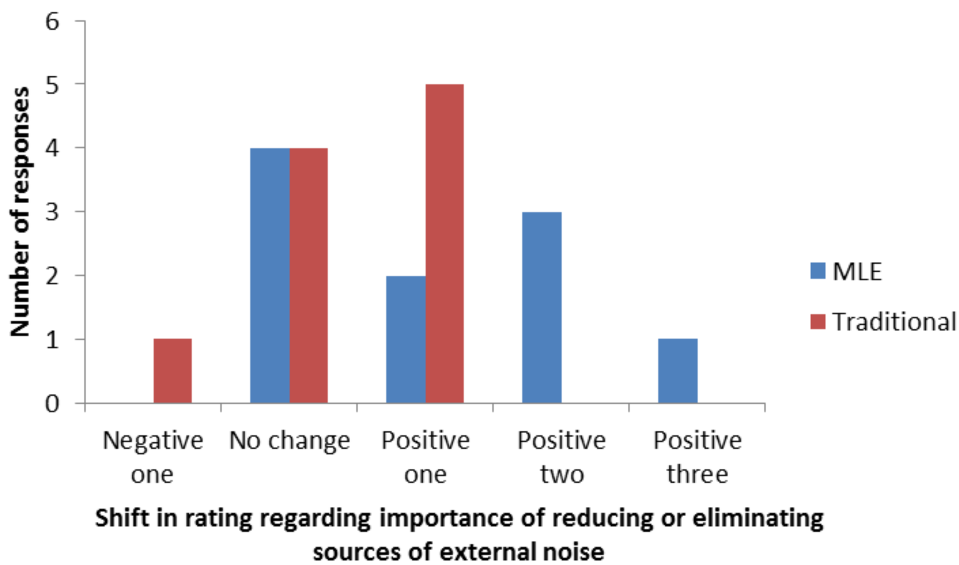

Figure 11: Shift in rating regarding the importance of reducing or eliminating sources of external noise between the pre-survey and the post-survey.

Based upon these results, we cannot reject the null hypothesis as it was found that there was no significant improvement in teachers' knowledge regarding the importance of eliminating external noise after the distribution of the information package.

Hypothesis 3:

Following the distribution of an information package, teachers' knowledge will improve regarding methods which could be implemented to reduce noise levels in the classroom with regards to:

c) Teachers' knowledge of reverberation

Change in individual responses between the pre and post survey was measured. A 'no' response was assigned a rating of 1, while 'yes – able to elaborate' was assigned a rating of 2. A negative score indicates a participant who selected 'yes' in the pre-survey now selected 'no' in the post-survey. A neutral score indicates the same response was selected across both surveys. A positive score indicates a 'no' in the pre-survey had changed to a 'yes' in the post-survey. Results are shown in Table 10 below.

Cross-tabulation showed a significant difference in the distribution of changes in responses between the pre-survey and post-survey for this question $\chi 2$ (1, N = 20) = 6.667, p = .03, indicating that teachers in the two different classroom environments (MLE versus traditional) had significantly different responses in the pre-survey and post-survey conditions. As shown, all teachers in traditional learning environments selected the same response in both pre and post-surveys. This differed in the responses from teachers in MLEs, where half of these participants showed improvement as they were now able to elaborate upon 'reverberation' in the post-survey whereas they could not in the pre-survey. The remaining half of MLE teachers' selected the same response in the pre and post-surveys.

Table 10: Individual changes in the post-survey score compared to the pre-survey scores regarding knowledge of reverberation.

		-1.00	*.00*	*+1.00*	*Total*
Classroom	MLE	.00	5.00	5.00	10.00
	Traditional	.00	10.00	.00	10.00
Total		.00	15.00	5.00	20.00

The results shown in Table 10 are depicted in Figure 12 below.

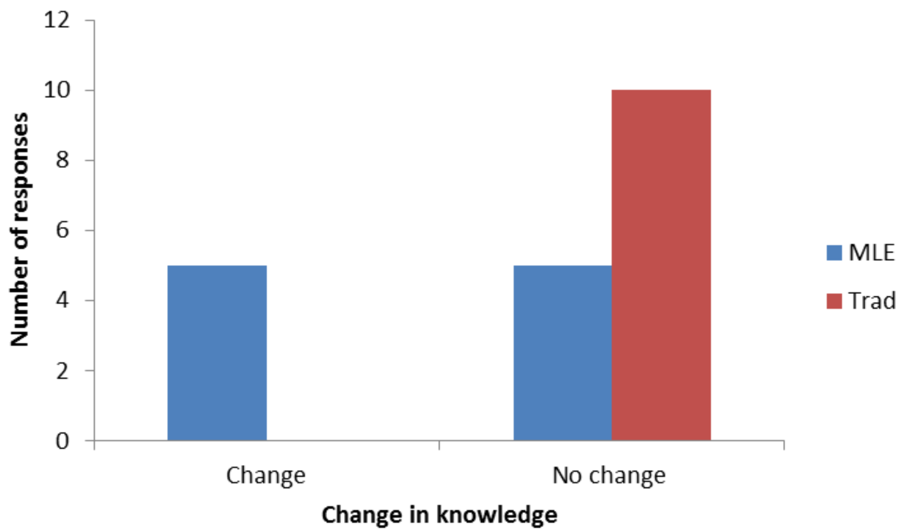

Figure 12: Individual changes in the post-survey score compared to the pre-survey score for teachers in MLEs and traditional learning environments.

Based on these results, the null hypothesis can be partially rejected. It was concluded that the change in teachers' knowledge of reverberation was significant for those teaching in MLE environments however this change was not statistically significant for those working in traditional learning environments.

Hypothesis 4:

Following the distribution of an information package, teachers' knowledge will improve regarding methods which could be implemented to reduce noise levels in the classroom with regards to:

d) Teachers' knowledge regarding whether acoustics have a direct effect on students' learning ability.

Teachers were asked whether they believed that classroom acoustics have a direct effect on students' learning ability. The results are shown in Figure 13 below. In the pre-survey, fourteen (70%) participants thought that classroom acoustics had a direct effect on students learning ability, while the remaining six (30%) believed they did not. In the post-survey, it was found that nineteen (95%) participants believed that classroom acoustics have a direct effect on students learning ability, while just one participant (5%) maintained they did not believe this to be true.

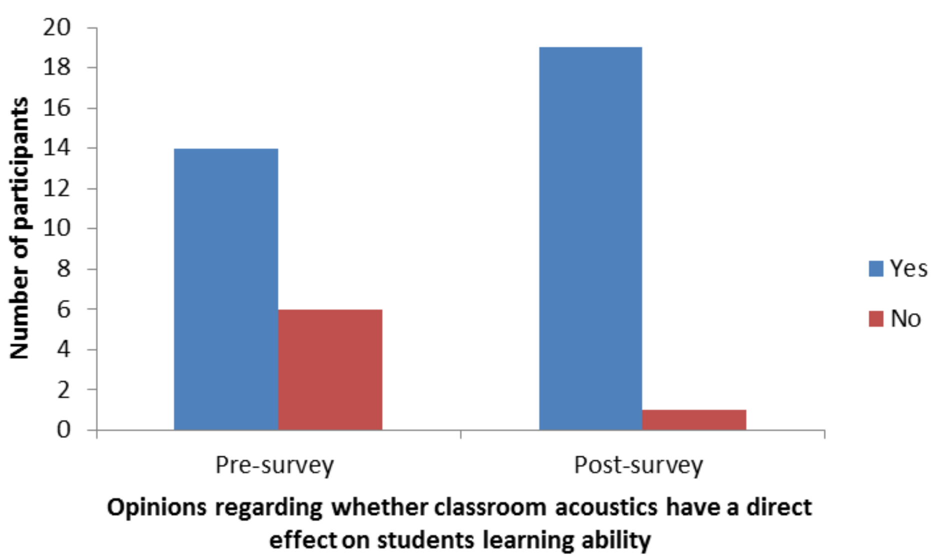

Figure 13: Teachers opinions in the pre-survey and post-survey regarding whether classroom acoustics have a direct effect on students learning ability.

In order to properly assess the change in opinion for each individual, it was necessary to analyse each response separately, shown in Table 11 below. A positive change indicates that a participant who previously believed classroom acoustics did not have a direct effect on students learning ability now believed that they do have a direct effect on students learning ability. Five (25%) participants responded positively. A negative response is indicative of the original belief that classroom acoustics have a direct effect on students learning ability changing to the belief that it does not. No participants fell into this category. A neutral response indicates the participant chose the same selection in both the pre-survey and the post-survey. Cross-tabulation showed no significant difference in the distribution of changes in responses between the pre-survey and post-survey for this question $\chi 2$ (1, N = 20) = .267, p = .606, indicating that teachers in the two different classroom environments (MLE vs traditional) did not have significantly different responses in the pre-survey and post-survey conditions.

Table 11: Individual changes in the post-survey score compared to the pre-survey score regarding whether classroom acoustics have a direct effect on students learning ability.

		Negative change	*No change*	*Positive change*	*Total*
Classroom	MLE	.00	7.00	3.00	10.00
	Traditional	.00	8.00	2.00	10.00
Total		.00	15.00	5.00	20.00

While qualitative improvements were shown regarding teachers' knowledge about whether acoustics have a direct effect on students' learning ability were present, these changes were not statistically significant. As such, we cannot reject the null hypothesis and it can be concluded that teachers’ knowledge regarding whether acoustics have a direct effect on students’ learning ability did not significantly improve following the distribution of the information package.

5.4 Training regarding classroom acoustics

Research question four:

(4) Are teachers are provided with any training with regards to classroom acoustics?

Teachers’ were asked whether they had ever attended any PD events regarding information about classroom acoustics and how listening environments can affect learning. Nineteen participants responded no (95%) while one participant had been provided with this opportunity throughout her teaching career (5%). As such, the null hypothesis cannot be rejected as the majority of teachers are not provided with any training with regards to classroom acoustics. This is shown in Table 12 below.

Table 12: The observed, expected and residual frequencies regarding the number of participants who selected each response about training with regards to classroom acoustics.

	Observed	*Expected*	*Residual*
Yes	19.00	10.00	9.00
No	1.00	10.00	-9.00
Total	20.00	20.00	0.00

5.5 Opinion about information package

Research question five:

(5) Is an information training package an effective PD option to implement in the future?

To conclude the survey, participants were asked whether the content of the information pack which was distributed as the intervention between the pre-survey and the post-survey had an influence over the way in which they chose to set up their classroom. Three teachers (15%) stated that the information pack had elicited change for them regarding their classroom layout. The majority of participants (75%) said that they had not yet implemented alterations but were currently thinking about ways which they could do this for the future. Two participants (10%) decided that this information pack would not change the way in which they set out their classrooms in the future. These findings are represented in Figure 14 below.

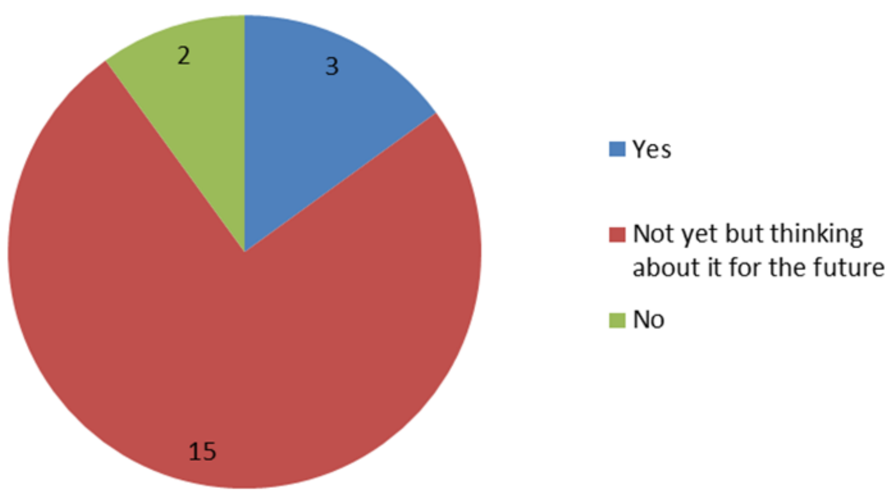

Figure 14: Teachers opinions as to whether the content of the information pack would alter the way they set up their classroom.

Cross-tabulation showed a variance in frequencies that was greater than based on chance alone, as shown in Table 13 below. As such, it can be determined that the observed distribution is not due to chance alone χ 2 (2, N = 20) = 15.700, *p* = .001, indicating that the classroom information pack had altered teachers' thinking about the ways they would choose to set up their classrooms in the future.

Table 13: The observed, expected and residual frequencies regarding whether the content of the information pack would alter the way participants set up their classroom.

	Observed	*Expected*	*Residual*
No	2.00	6.70	-4.70
Not yet, but thinking about it	15.00	6.70	8.30
Yes	3.00	6.70	-3.70
Total	20.00		

DISCUSSION

The present pilot study investigated the knowledge held by NZ primary school teachers regarding classroom acoustics and the effectiveness of an information package for improving teachers' knowledge of classroom acoustics. The purpose of this chapter is to consider the findings with respect to the existing literature and explore the subsequent practical implications. This will be achieved by addressing each research question individually before further investigating deeper aspects of each underlying concept.

The first hypothesis was that teachers of MLEs would rate their classroom listening environment as poorer than their colleagues teaching in traditional learning environments (Finitzo-Hieber, 1988; Mealings et al., 2015). This was deemed an essential area of investigation, as the conversion towards MLEs in now integral to the 10YPP governing the continuing development within NZ primary schools, despite evidence from the 1970s that suggests noise can be a major problem in these spaces (see Shield, Greenland & Dockrell 2010 for review). The results from this pilot study found that the difference between ratings of the classroom listening environment from teachers working in MLEs in comparison to those in traditional learning environments was not significantly different. This finding was in contrast to the expected hypothesis and in conflict with research which reported that teachers in MLEs rated their listening environment more poorly than their counterparts teaching in traditional learning environments (Finitzo-Hieber, 1988; Mealings et al., 2015). The deviance of results from the hypothesised outcome may be consequential of this study differing from previous research in a variety of ways. For example, the ecological validity of this study may be reduced due to classroom size not being controlled for. Participants in this pilot study were not asked to elaborate upon their classroom population, which may have contributed to the results differing from the expected outcome based on previous research (Mealings et al., 2015). In the research by Mealings et al. (2015), the smallest population ranged from single-celled classrooms with 25 students, whilst the largest MLE hosted 205 students. Intrusive noise levels in classrooms with over 90 students were excessive and well above the recommended levels (Mealings et al., 2015). Furthermore, it cannot be assumed that similar variance in classroom population from Australian research (Mealings et al., 2015) can be found within the NZ classrooms utilised within this pilot study. Subsequently, this may have contributed to the opinions of teachers in this pilot study differing from the literature (Mealings et al., 2015).

The current study also differed from previous research that investigated aspects of teachers' knowledge regarding classroom acoustics with respect to the number of participants used (Ramma, 2015; Valentine et al., 2002). This pilot study utilised fewer participants (n = 20) compared to Valentine et al. (2002) (n = 113) and Ramma (2015) (n = 70). Subsequently, the reduced power of the current study could account for a portion of the difference in findings, however, Mealings et al. (2015) used a sample size (n=18) which is comparable with the size of the cohort within this study. Bennet et al. (1980) identified a triad of open-plan classroom designs; (1) fully open plan (large degree of openness and teaching groups divided only by means of moveable furniture), (2) semi-open plan (teaching spaces defined by means of walls but with large openings without doors in them), and (3) flexible open plan (teaching group areas opened or closed off easily by means of sliding or folding partitions). As such, not controlling for the degree of 'openness' in each MLE classroom involved in this study as was accounted for in Mealings et al. (2015) may have contributed to results which diverged from the expected hypothesis despite the similar sample size between Mealings et al. (2015) and the present study.

Obtaining the professional opinion of acoustic consultants and educational audiologists is recommended for achieving optimal acoustic design (Ramma, 2015). Lowered noise levels have been proven when rooms were treated with the addition of an absorbent ceiling (MacKenzie & Airey, 1999). Rooms with less effective acoustic treatments have higher measures of background noise levels due to the café effect (MacKenzie & Airey, 1999). As such, to more accurately assess whether teachers' ratings of their listening environment were appropriate based on the standards of their classroom environment, it would have been beneficial to assess whether the classroom was built or modified under the guidance of an acoustic consultant or an educational audiologist, as well as assessing whether the classroom had previous physical modifications to enhance the acoustic characteristics, and whether any hearing-assistive technologies were routinely applied to overcome the issue of superfluous classroom noise (ASHA, 2005).

Qualitative data were analysed so that small differences in teachers' opinions could be recognised. As depicted in Table 2, the qualitative thematic analysis depicted that teachers in MLEs tended to consistently rate their classroom listening environments as poorer than those working in traditional single-celled classrooms, although this difference was not statistically significant. This finding differed from that of Shield, Dockrell and Rigby (2004) who found a significant relationship between the number of children in a classroom and the level of ambient and background noise in the classroom. Despite this, the general trend observed was similar to information found by Mealings et al. (2015), who reported that teachers of single-celled classrooms had lower levels of agreement with positive statements about open-plan classrooms than teachers who already worked in larger classroom environments. The vast majority of teachers in open-plan classrooms rated their listening environment as 'poor' and were of the opinion that their students experienced difficulties focussing in open-plan settings (Mealings et al., 2015). This is a logical finding, as constant exposure to noise results in additional demands being placed on children with regards to their listening effort (Shield & Dockrell, 2010). As a consequence, the attentional and cognitive resources available for linguistic and cognitive processing are reduced (Anderson, 2001), meaning children can tune out from auditory overload (Anderson, 2001; Maxwell & Evans, 2000). This results in increased risk of missed learning opportunities. Children who have a hearing loss, regardless of the cause, are at an increased level of susceptibility to responding incorrectly to instructions, as well as being inattentive and unfocused (Brackett, 1977). Because hearing loss is an invisible challenge (Ross, 1991), those around the affected individual are not always aware they are affected by the receipt of, or processing of, a compromised auditory signal. This is especially true in primary school-aged children with a high prevalence of OM, as the hearing loss may fluctuate regularly depending on the viscosity of the fluid against the middle ear mechanism (Bluestone & Klein, 2001). Consequently, when there are increased reports of students experiencing difficulties focussing in open-plan settings (Mealings et al., 2015), it is also important to consider the potential presence of confounding factors such as fluctuating or chronic OM causing further detrimental repercussions to a child's listening ability (Silva, Chalmers, & Stewart, 1986).

The second research question aimed to investigate which noise sources detrimentally affect the classroom listening environment. The findings were conducive with the expected hypothesis. In the pre-survey, 65% of participants specified that they experienced difficulties in the classroom with noise generated by internal sources, a percentage which increased to 85% in the post-survey - a finding in line with previous literature (Mealings et al., 2015). The dissatisfaction criterion utilised by Shield et al. (2008) stipulated that a minimum of 68% of people need to be satisfied with the listening environment in order for it to be deemed acceptable. Accounting for this factor, many of the classrooms in this pilot study are at risk of violating these criteria. A commonly reported source of bothersome internal noise identified in this pilot study was child generated noise, a finding which is in agreement with previous research (Mealings et al., 2015; Shield, Dockrell & Rigby, 2004).

Noise generated inside the classroom was more likely to be perceived by teachers as bothersome in comparison to external noise (Valentine et al., 2002), a result mirrored in the qualitative results from this pilot study. In order to identify specific areas of concern regarding sources of internal noise, trends in commonalities between reported 'other' sound sources were investigated. As depicted in Figure 7, three reported 'other' categories in the pre-survey were indicative of equipment generated noise (i.e., heat pump, iPads and/or computers and plumbing noise), while the remaining category focussed on human-generated noise, created by both students and teachers alike. The post-survey depicted a wider range of responses which spanned across six categories. Four participants identified iPads and/or computers as 'other' bothersome internal noise sources. The fact that a total of eight participants elaborated upon equipment generated noises as bothersome using the open-ended questions suggests a potential correlation between high internal noise levels and the shift towards the inclusion of digital technology in modern teaching pedagogy. Further to this, of the eight sources of noise reported in the 'other' category in the post-survey, seven were direct consequences of equipment noise. More participants were inclined to elaborate upon 'other' responses in this pilot study compared to those in the study by Valentine et al. (2002). This may be a consequence of this pilot study utilising a self-selection design, meaning all involved were willing participants, whereas Valentine et al. (2002) used random sampling to send questionnaires to 122 teachers, of whom 93% chose to participate. Of those who did provide an 'other' response in the research by

Valentine et al. (2002), the specifics of what was described were not explained within the discussion section – meaning, similarities between responses to this pilot study cannot be measured.

In a study which investigated adolescents' perceptions of their classroom listening environments, the majority of students rated internal noise sources such as students talking or moving around as being the predominant reoccurring sound during lessons (Connelly, Dockrell, Shield, Conetta, & Cox, 2013). This finding was consistent with previous research (Astolfi & Pellerey, 2008; Shield, Dockrell & Rigby, 2004; Kennedy, Hodgson, Edgett, Lamb, & Rempel, 2006). Despite this, the regularity of the sound did not correlate directly with the annoyance of the sound. Measures of external noise, inclusive of intrusive sounds such as machinery, provoked the highest annoyance ratings, despite the fact that these sounds were not consistently present (Dockrell & Shield, 2002). This finding reflects that of previous research which suggests that the degree of annoyance elicited by a sound is determined more strongly by its unpredictability and intrusiveness than its level of proximity (Guski, Felscher-Suhr & Schuemer, 1999). This finding has positive implications for the practicality of reducing distracting intrusive noise from permeating into the classroom listening environment. It suggests that the strongest noise sources resulting in the disruption of learning occur in a transient form, meaning that the likelihood of these sounds being managed through liaising with the likes of maintenance and construction companies could be increased. On average, 60% of the participants in this pilot study indicated that they experienced issues with external noise entering the classroom, a percentage which was smaller than expected based upon similar research (Shield & Dockrell, 2002; Valentine et al., 2002). It is hypothesised that the potential reasons behind the disparity in opinions between these studies could be attributed to differences in the geographical locations of each participating school. Shield and Dockrell (2002) investigated noise sources outside schools in London and found that the predominant causes were cars (outside 86% of schools) and aircraft (outside 54% of schools) with a smaller proportion being affected by other vehicles such as trucks, buses and trains. The distributions of these causes of noise are comparable to sources which were recorded in another urban setting within the UK during the 2000/2001 National Noise Incidence Survey (Building Research Establishment, 2002). Subsequently, the author proposed that these values have sufficient ecological validity to be extrapolated as a reflection of the typical noise exposure of schools in similar industrial societies. Valentine et al. (2002) carried out their research solely within schools in the Auckland region of NZ, which due to larger population, is an area which is at a greater likelihood of being exposed to an increased level of vehicular noise compared to the schools in this pilot study which were located within Christchurch and the more rural settings of the wider Canterbury region.

After identifying which noise sources detrimentally affected the classroom listening environment, it was deemed important to investigate strategies which could be implemented to mitigate the resultant negative consequences. As children working in primary school classrooms are often exposed to a variety of different noise sources, the feasibility of reducing contact with all sources of detrimental noise is challenging. Therefore, it is important to identify and target the effects of specific noise sources on performance and behavioural variables (Shield, Dockrell & Rigby, 2004). As such, pragmatic explanations have been sought to identify the different effects that internal and external noise sources will have on a child's potential to learn.

Teachers tended to be more accommodating of higher levels of classroom noise if the majority of noise was perceived as being generated by learners on the property as opposed to sources external to the school environment (Manlove, Frank & Vernon-Feagans, 2001). The reason teachers were more likely to accept noise generated by children is that it has become generally accepted as the 'price of doing business' (Manlove et al., 2001. p. 55) despite the fact that meaningless, irrelevant speech noise from adjacent rooms has been proven to have greater interference on speech perception than other types of noise (Boman, Enmarker & Hygge, 2005). High noise levels not only adversely affect children's speech perception (Crandell & Smaldino, 2000; Finitzo-Hieber & Tillman, 1978), but also their reading and language comprehension (Klatte, Lachmann & Meis, 2010; Maxwell & Evans, 2000; Ronsse & Wang, 2013), cognition, concentration, and their psychoeducational and psychosocial achievement (ASHA, 2005; Crandell & Smaldino, 2000; Shield et al., 2010). When teachers in the present pilot study were asked about the importance of eliminating or reducing external noise from infiltrating into the classroom, no significant effect was found regarding the type of classroom environment each participant taught in and their resultant opinion regarding the importance of eliminating or reducing external noise. Despite this, it was found that there was a significant shift between the pre-survey and the post-survey. Teachers were significantly more likely to report the importance of eliminating or reducing external noise as higher in the post-survey, indicating a change in knowledge regarding this construct throughout the duration of this pilot study.

Despite the conclusive findings which support the negative impact excess background noise has upon children's learning, relatively few strategies exist regarding approaches to modulate the effects of disproportionate noise levels (Dockrell & Shield, 2006). To investigate the current climate amongst NZ primary school teachers with regards to their thoughts on managing noise, the third research question sought to reveal whether the distribution of an information package improved teachers' knowledge about what could be done to eliminate excess external noise in the classroom.

The first component of this research question was that following the distribution of an information package, teachers' knowledge would improve regarding methods which could be implemented to reduce excess external noise from entering the classroom. Responses from the pre-survey indicated that just under half of the respondents were unsure of a way they could reduce excess noise. Of the remaining participants who provided suggestions, two respondents indicated they regularly close the windows to reduce excess external noise from permeating into the classroom. An additional three participants provided responses indicating the use of additional soft furnishings, thick curtains or absorptive ceiling and wall tiles would be beneficial towards reducing this issue. These findings were encouraging, as the resourcefulness in some of the responses received in the post-survey were mirrored in the findings of Mealings et al. (2015), who discovered that teachers in open-plan environments were being creative in utilising differing coping strategies to deal with excess noise as opposed to solely raising their voice.

While there was a qualitative increase in the number of suggestions that MLE teachers were able to provide to reduce external noise from infiltrating into the classroom following the distribution of the information package, this difference was not significant. Despite this, some useful suggestions were reported in the results of the post-survey. For example, participant M suggested the addition of soft furnishings to absorb noise, along with the use of screens and thick curtains. This same participant suggested asking the principal to change the lawn mowing time to outside of school hours or to the weekends. Participant N stated that they would request a school-wide discussion around ways the staff and board of trustees could work together to help reduce excess noise levels. Another participant also suggested the inclusion of soft furnishings in the cloak bay to absorb any outside noise and the addition of mats to the floor.

Many of these reported suggestions correlated directly with the material presented in the information pack which was promising, as it suggested the information delivered could be useful and applicable to enacting practical change. One point to consider regarding the addition of extra soft furnishings within the classroom is the resultant risk this poses in terms of fire hazard if these furnishings are not fire retardant (Nicholson & Nolan, 1983). This should be discussed with the school prior to the implementation of additional soft furnishings. This may provide good leverage for the installation of acoustic ceiling and wall tiles as these remain the gold standard for acoustic treatment, however, some schools are reluctant to install them due to expense. International research has specified that classrooms with absorbent ceilings (with or without carpet) achieve a RT within the recommended guidelines for open-plan classrooms, whereas open-plan classrooms without absorbent ceilings tend to exceed this reference (Greenland & Shield, 2011). While the responses from this question indicated qualitative developments in knowledge, significant changes were found with regards to the second component of the hypothesis. The second component of this hypothesis was that following the distribution of an information package, teachers' knowledge will improve regarding the importance of eliminating or reducing external noise. A significant improvement in teachers' knowledge regarding the importance of eliminating or reducing external noise was found following the distribution of the information package.

The third component of this hypothesis was that the distribution of an information package would improve teachers' knowledge regarding reverberation. In order to investigate this construct, participants were asked whether they had heard of the term reverberation. If their response was positive, elaboration upon a definition was required. It was thought that any negative changes in knowledge of the term 'reverberation' in the post-survey compared to the pre-survey may have been attributable to lexical confusion, as 'reverberation time' was defined in the information package, though the term 'reverberation' itself was not. Despite this, no participants across either of the classroom groups showed a negative change in their ability to elaborate upon reverberation. Interestingly, all participants in traditional learning environments selected the same response in the post-survey as they did in the pre-survey meaning no changes in knowledge were recorded from this subset of participants. Despite this, 50% of those teaching in MLEs showed a positive change in their ability to elaborate upon a definition for the term 'reverberation', a percentage indicative of a statistically significant change.

The fourth component of this research question was that the distribution of an information package would improve teachers' knowledge regarding whether acoustics have a direct effect on students' learning ability. Qualitative improvements were apparent in the post-survey results, however, these improvements did not reach a level of statistical significance. These findings were comparable to the knowledge of participants in the study by Ramma (2015), where the majority of participants agreed with the statement that if learners' speech perception was compromised as a consequence of poor classroom acoustics, then overall academic achievement would be detrimentally compromised. Adversely to this, however, when the same subset of respondents were asked to rate the impact that too much background noise and too much RT would have on the listening environment, most were of the opinion that these factors would have only a small to average impact on learning. The author proposed that an underlying reason for this disparity could be attributed to the fact that topics like background noise and vocal volume are generally intuitive to the average teacher (Ramma, 2015). Subsequently, teachers may be familiar with these words and phrases as they are an integral part of the everyday educational setting; however despite this baseline familiarity, this does not necessarily mean that teachers are fully aware of the impact these factors may have on speech perception and consequent learning in the classroom (Ramma, 2015).

The fourth research question asked participants whether they had received any formal input regarding classroom acoustics or about ways in which the listening environment can affect students' ability to learn. It was found that the overwhelming majority had not received this throughout their teaching careers. Subsequently, it is clear that there is a need for further PD training which is supported by Valentine et al. (2002), who recommended that teacher training and PD days should include more information regarding the importance of acoustics in all types of classroom environments. This evidence provides a rationale to support the inclusion of the topic of classroom acoustics in future PD training days. In an article regarding the transition towards MLEs, a principal had commented that schools should not be responsible for seeking help from the MoE to enrol in PD programmes (Redmond, 2017). To avoid transitions into MLEs solely occurring at an architectural level, this principal believes that the MoE should automatically offer PD orientation around the adoption of and adaption to modern learning practices. Consequently, investigations were made into what PD options are available to NZ schools regarding classroom acoustics and transitions into MLEs.

Primarily based in Christchurch, CORE Education is a professional learning and development organisation facilitated across both English and Māori mediums. Its underlying aim is to provide a diverse range of innovative solutions to support both educators and learners in PD training. A consultant was contacted regarding the options that CORE Education offers for NZ primary schools regarding transitioning towards modern teaching practices (CORE education staff member, personal communication, 14th July 2017). It was discovered that schools choose which style of PD course would best suit the needs of their staff. Three potential options exist.

The first of these is face-to-face contact, also known as the Enable course, which runs over the duration of half a day. The second option is a blended workshop which provides a mixture of face-to-face and online learning, which runs part-time for the duration of between eight to ten weeks. Finally, the school can opt for an online course, which is known as the Empower programme and runs part-time for twenty weeks. An additional option known as Transform also exists, which involves personalised training which is long-term and strategic, meaning it is responsive to the goals of the enrolled school.

Research was carried out to investigate whether any other PD courses were available for NZ primary schools through the different organisations. A myriad of different options were found. The organisation Cyclone provides a team of fully qualified teachers who also work as digital learning specialists. Their focus orientates around PD for strategic planning, mentoring and the movement towards digital fluency. This could provide benefit as accompanying the present change in teaching pedagogy comes the need to remain flexible and adaptable. Cyclone aims to work with teachers to develop, engage and sustain pedagogies, regardless of their current level of digital fluency.

Cognition Education was also contacted to discover what information they could provide teachers with regards to PD training for MLEs. Similarly to CORE Education, Cognition Education runs PD workshops tailored to MLEs. Courses can be delivered either face-to-face or in an online format. When questioned about the length and content of the courses, it was discovered that each course is tailor-made depending on the needs and requests of the school (Cognition Education staff member, personal communication, 18th July 2017). This involves a discovery phase, where a representative of the school collaborates with the company to discuss what type of intervention is needed, and this is subsequently created and delivered via the agreed medium. Independent organisations which offer PD courses are another avenue which some schools could choose to explore. Evaluation Associates are an independent education consultancy company who specialise in providing PD, strategic advice and research within the education sector. They offer a full day workshop which is primarily targeted towards teachers who are beginning to investigate concepts associated with MLEs. The course covers ideas, terms and theories associated with teaching in a MLE, while also offering practical advice on how to implement these ideas within the classroom.

In order to gain access to the PD programmes, it is expected that schools request the assistance of organisations such as CORE Education when they feel their staff need PD support (CORE education staff member, personal communication, 14th July 2017). Funding for these courses varies depending on the nature of the school. If the school is private, the fees associated can be paid directly by the school to the company. Public schools have access to the centrally funded professional learning and development scheme, which is beneficial as this allows these training courses to become accessible to a greater proportion of staff members.

The idea that PD is conducive to improvements in teaching is widely accepted (Kennedy, 2016). Despite this, mandated PD has been shown to be less effective compared to PD that is undertaken voluntarily (Kennedy, 2016). This issue is analogous to that faced by many teachers in the classroom; that “attendance is mandatory but learning is not” (Kennedy, 2016. pg. 29). In a review investigating how PD improves teaching methods, it was found that the average effect of studies which relied on volunteer participation showed a greater level of effectiveness than those requiring mandatory attendance (Kennedy, 2016). Furthermore, it was found that PD programmes were more effective when they took into account the slow and incremental techniques that teachers utilise to incorporate novel ideas into their on-going practice

(Huberman, 2004). This means that the PD programmes which facilitate optimum effectiveness and retention of information tend to monitor their participants in a follow-up period between one to two years later to provide additional support when required.

The final research question aimed to investigate whether an information package would be an effective training option to implement in the future. As the majority of teachers in this pilot study stated that the information package had made them think about alterations they could make to improve their classroom listening environment, the hypothesis was able to be accepted based on statistical significance, albeit somewhat tentatively due to potentially altering caveats which will be discussed further in the limitation section. Following the distribution of the information package, approximately one-third of participants showed positive improvement in their ability to elaborate on methods which could be utilised in reducing external noise entering the classroom. This improvement brought the total number of participants who felt confident to elaborate on different methods they now felt confident to utilise up to three-quarters of all participants included in the study. While this change did not reach levels of statistical significance, it provides qualitative support for the notion that the information package distributed provided participants with useful ideas regarding reducing external noise levels which have the potential to be implemented in NZ primary schools. This is further supported by the significant change in the post-survey compared to the pre-survey regarding the increase in rating of the importance of reducing or eliminating external noise.

Positive improvements were shown regarding improvements for teachers working in MLEs between the pre-survey and post-survey regarding their knowledge of, and ability to elaborate on the term 'reverberation'. Interestingly, this change was only significantly different for teachers in MLEs, indicating that teachers in the two different classroom environments (MLE versus traditional) had significantly different responses in the pre-survey and post-survey conditions. All teachers in traditional learning environments selected the same response in both pre and post-surveys. This differed to the responses from teachers in MLEs, where half of these participants showed improvement as they were now able to elaborate upon 'reverberation' in the post-survey whereas they could not in the pre-survey. This disparity may be a consequence of not controlling for the potentially confounding impact of extraneous variables prior to the commencement of the study, which will be discussed further in the limitations section below.

While these benefits show positive repercussions with regards to improving knowledge, the improvements in knowledge noted in the post-survey condition may not be a direct consequence of the material provided in the information package. The improvement in responses could be credited to participants achieving heightened awareness regarding the subject of classroom acoustics secondary to their participation in this pilot study, and consequently carrying out autonomous research surrounding aspects of this topic where they felt further information would be beneficial. Additionally, qualitative improvements were shown regarding improvement in teachers' knowledge about whether acoustics have a direct effect on students' learning ability. While this improvement did not quite reach a level of statistical significance, it was promising to see that by the conclusion of the post-survey, 95% of all participants in the study believed that classroom acoustics would have a direct effect on students' learning ability.

In order to understand how to further improve the effectiveness of this intervention, a comment discussed earlier by a principal when discussing the subject of PD should be revisited (Redmond, 2017). The principal in question suggested schools should not have to approach the MoE for PD programmes. Instead, it was proposed that the MoE should implement PD workshops for all schools converting to MLEs. This viewpoint goes against the recommendations found by Kennedy (2016) which suggest that mandated PD is less effective than voluntary PD. As such, this raises the question of how to best engage teachers' interest in the area of classroom acoustics so that voluntary PD becomes an appealing option.

A potential solution to this conundrum arose from the feedback gathered from some participants at the conclusion of the study. Participant G said that the distribution of the information package had made her more aware of a subject which she had not given a great deal of thought to but subsequently realised that she should have. Another participant said that the study made her much more interested to consider the impact of noise in the classroom and to look into methods regarding how best to combat this. These comments are indicative of the positive feedback surrounding the distribution of the information package. The majority of comments mentioned concepts indicative of the information package being beneficial and stimulating, in addition to raising thoughts regarding the matter of classroom acoustics which had not been deliberated upon previously. Consequently, an advantageous notion could be to distribute a similar type of concise, readable information package to all teachers in primary schools across NZ. This would build upon similar research by Gunn and Pitt (2003), and would provide teachers with the opportunity to digest relevant, readable information regarding classroom acoustics. From this point, it could be a voluntary decision to embark on further PD workshops run by the companies detailed above and organised by the school. Teachers who register their interest could be supplied with further PD training. Those who do not have any interest in this would have been supplied with a subset of information by means of the information package, which as participant D said, "… should make them more aware of the subject in the future". Unfortunately, the small proportion of teachers who indicated that the information package had not altered the way they would choose to set up their classroom did not elaborate on their reasoning behind this.

6.1 Study Limitations

This study had several limitations related to sample size, study design, survey design and geographical location of the participating schools, meaning that the current study's findings should be considered with respect to its limitations.

The first limitation was that this study was of a pilot nature meaning that only twenty participants were recruited. This was a small number of participants to be involved in a study with a survey design. Consequently, these findings need to be interpreted with caution and not be overgeneralised as the study was at risk of being underpowered. In order to address this issue in future research, it would be beneficial to extrapolate the study from a pilot design and examine a larger participant population grouped by type of classroom. This would provide more power for statistical analysis and allow for generalised conclusions to be drawn regarding how teachers cope with listening conditions in differently sized classrooms. This may improve understanding regarding which designs and acoustic treatments are appropriate and what the maximum number of children in a classroom area is possible in open-plan areas to maintain adequate speech perception. It is important that future research uses approaches that take into account the physical acoustic conditions in the classrooms (i.e. the noise levels, SNR and RT's).

The second limitation was the lack of control group. A staggering method should have been utilised in the study design which included the implementation of a control group. To maintain ethical standards, those participants in the control group would then have been provided with the information package after the post-survey had been completed so that their access to knowledge was not restricted based on their allocation within the survey design. Lack of a control group means it is difficult to attribute the changes in participant responses as a direct reflection of knowledge gained from the information package. While many improvements in the post-survey can be assumed to be a result of the distribution of the information package due to the responses reflecting specific suggestions and ideas which were included in the package, this cannot be conclusively determined. The improvement in responses could be attributed to participants becoming more aware of classroom acoustics as a subject as a consequence of the pre-survey, and subsequently carrying out independent research into methods they could utilise to enact improvements to their classroom listening environments.

The third limitation associated with this study was that due to the method of participant selection, it was not possible to control for the location of the school or its decile rating. As mentioned previously, those schools situated in urban settings are more likely to experience intermittent sound interruptions than schools located in quieter, more rural settings (Shield & Dockrell, 2002). As such, variance in physical location may have altered the baseline classroom listening environments of each school and subsequently, it is not possible to accurately generalise the findings of this study to all teachers or schools across NZ. Further to this, the decile of the school may have influenced the quality of resources and the type of spatial configurations, noise, heat, cold, light, and air quality within the classrooms. Additionally, teachers were not asked how many students were in their classrooms. The number of students in each environment would have provided a useful context in assessing the responses received from teachers regarding their classroom listening environments.

The fourth limitation associated with this research orientated around the design of the survey. While the survey created was modelled off two surveys which had been successfully utilised in previous domestic and international research (Ramma, 2015; Valentine et al., 2002), no evidence was found that either of those surveys had been peer reviewed. Additionally, as a result of information in this study being obtained using a questionnaire with predominantly close-ended questions, participants were somewhat limited in their ability to elaborate on their responses to all questions, although they were provided with the opportunity to add comments about any thoughts they wanted to share at the conclusion of the survey.

The potential confounding impact of extraneous variables could have been reduced had Fisher's Exact Test been conducted upon demographic variables prior to commencing the analysis of the results. Was a significant difference to exist in the results, this would have determined whether these disparities were attributable to other factors such as: number of years spent teaching, the location of training, personal experience with hearing loss, or the age of the participant. This was unable to be carried out sufficiently as questions regarding these variables were not included in the survey. While data regarding whether each participant had taught a child with hearing loss was shown not to significantly influence teachers' responses, it would have improved the validity of this study to assess the totality of responses with regards to the extraneous factors listed above. Additionally, data gathered through the recruitment process indicated that of the sample population, 19 participants were female whilst only one was male. While this is likely a consequence of teaching being a female-dominated profession (Drudy, 2008), obtaining a more heterogeneous sample may have been beneficial for improving the ecological validity of this study.

Finally, the generalisation of these results was limited due to the exploratory pilot nature of the study. For future research in this area, it is recommended that the study is replicated with larger numbers, a staggered control group design and increased control regarding the selection of participating schools.

6.2 Future research directions

The use of sound-field amplification (SFA) has been effectively proven to mitigate adverse classroom acoustics by increasing the overall speech level of the teacher, improving the SNR, and producing uniform speech levels in the classroom regardless of the teachers' position (Flexer, 1994). These improvements create a more favourable learning environment which can benefit almost all children (Palmer, 1997). While some MLEs have already incorporated SFA systems, an interesting area of future research could investigate the SNR in MLE classrooms using SFA compared to those not using SFA. This would be an excellent area of research to investigate in the near future. If significant improvements were found for speech understanding in MLEs, this could be a key piece of technology to include in upcoming new MLE buildings before they are all converted or built without the use of these systems. Longitudinal studies would specifically demonstrate whether intensive, focused and acoustically enhanced interventions are able to maintain long-term listening benefits. McLaren and Page (2016) emphasised that with the increased interest in the effects of noise on education and performance, there is an increased importance for future studies to have regimented use of suitable and calibrated equipment, accurate notation, and robust study design in order to obtain accurate results.

As it is becoming increasingly common to integrate children with hearing impairments into mainstream classrooms, another beneficial area of future research would be to investigate how children with special educational needs rate listening conditions in MLEs. Research has shown that children with hearing impairments, auditory processing disorders, language delays and attention deficits need noise levels to be 10dB lower than their peers, meaning it is important the listening environment for these children is favourable (Crandell & Smaldino, 2000; Konza, 2008; MacKenzie & Airey, 1999; Nelson & Soli, 2000). A recent study by Connolly, Dockrell, Shield, Conetta, and Cox (2014) found that adolescents aged between the ages of 11 and 16 with special educational needs, including hearing impairments, reported higher rates of annoyance due to noise along with increased sensitivity to the detrimental effects of noise when compared to their normal-hearing peers. Subsequently, it would be worthwhile to explore these effects in primary school aged children in MLEs.

Additionally, benefit could be gained from conducting further research into the successful implementation of PD programs regarding classroom acoustics. The results of this study highlight the need for more schools to supply information around classroom acoustics to their teachers, especially given the current MoE policy which is enforcing the shift towards all state-owned primary schools operating as MLEs.

In a domestic context, the SNR in traditional single-celled classrooms ranges between -5dB and +10dB. This adheres to the acceptable level of +15dB identified by Nelson & Soli (2000). A useful area for investigation in the future would be to replicate this study in MLEs to assess whether the SNR still falls within an acceptable level. Similar investigations with regards to RTs are also warranted. As mentioned previously, the RT recommended by the MoE for flexible learning spaces is 0.5 to 0.8 seconds whereas the recommended RT for traditional single-celled classrooms is 0.4 to 0.5 seconds (MoE, 2016). It would be an interesting area of future research to measure the RTs in MLEs to assess whether they adhere to the recommendations set out by the MoE, as excess RTs have a detrimental effect upon the classroom listening environment (MoE, 2016).

6.3 Concluding remarks

The current study aimed to investigate teachers' knowledge of classroom acoustics. The results emphasised the need for implementation of PD programmes or a similar intervention to help improve teachers' knowledge of classroom acoustics, especially given the current recommended transition towards MLEs. From a practical perspective, these findings have important implications regarding the support required for teachers when their schools begin the transition process. It is recommended that schools should foster strong and meaningful collaborative relationships with targeted organisations beyond the school to help support teachers in their knowledge and learning. It is hoped that future research will be carried out to continuously monitor the RT and SNRs within future MLEs to ensure that modern classrooms are being built to the recommended standard. Further to this, it would be beneficial for future research to continue to investigate and support teachers in their pursuit of knowledge regarding classroom acoustics, especially as the transition towards MLEs permeates throughout all state-owned NZ primary schools. While a strong acoustic signal is beneficial for all children's learning, increased prevalence surrounding the integration of hearing-impaired children into the mainstream education system is placing an increased level of importance on the issue of classroom acoustics. This is especially imperative considering the present shift towards MLE classrooms, and it is essential that teachers are provided with sufficient support to assist them in optimising their classroom listening environment.

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Appendices

APPENDIX A: *ETHICAL APPROVAL*

Letter of ethical approval, University of Canterbury Human Ethics Committee.

UC
UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

HUMAN ETHICS COMMITTEE

Secretary, Rebecca Robinson
Telephone: +64 03 369 4588, Extn 94588
Email: human-ethics@canterbury.ac.nz

Ref: 2017/06/ERHEC-LR

19 May 2017

Megan Dempster
Department of Communication Disorders
UNIVERSITY OF CANTERBURY

Dear Megan

Thank you for submitting your low risk application to the Educational Research Human Ethics Committee for your research proposal titled "Teachers' Understandings of the Ministry of Education Acoustic Guidelines".

I am pleased to advise that this application has been reviewed and I confirm support of the School's approval for this project.

With best wishes for your project.

Yours sincerely

pp R. Robinson

Dr Patrick Shepherd
Chair
Educational Research Human Ethics Committee

Please note that ethical approval relates only to the ethical elements of the relationship between the researcher, research participants and other stakeholders. The granting of approval by the Educational Research Human Ethics Committee should not be interpreted as comment on the methodology, legality, value or any other matters relating to this research.

F E S

APPENDIX B: *RECRUITMENT*

B.1 Research information sheet (page 1 of 3)

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Research Information Sheet

Study Title: Teachers' understanding of the Ministry of Education acoustic guidelines.

Primary Researcher:

Megan Dempster

MAuD student

Department of Communication Disorders

University of Canterbury

Email: mde85@uclive.ac.nz

Phone: 02102406741

Why have I been contacted?

We contacted you to invite you to take part in the study**: Teachers' understanding of the Ministry of Education acoustic guidelines.**

What is the aim of the study?

This project aims to investigate teachers' understandings of the Ministry of Education (MoE) acoustic guidelines. This information will be used to help create a set of teacher-friendly guidelines which will assist setting up classrooms to be optimal listening environments.

Who do you need for the study?

To be a current teacher of year one students in a primary school or have been a year one teacher within the past five years.

B.1 Research information sheet (page 2 of 3)

What will happen in the study?

You will be asked to participate in a short pre-assessment survey regarding the recently reviewed Ministry of Education acoustic guidelines. You will be provided with a concise information pack which will provide suggestions for ways which you could set up their classroom for optimal listening conditions.

A post-assessment will be distributed after this to determine whether the information you received in their package was informative and affected the way you will consider setting up your classrooms in the future.

You are welcome to bring up any questions or concerns you may have with this process.

What are my rights?

Participation in this study is voluntary – it's entirely up to you. You can withdraw from the study at any time, without giving a reason. This will not affect any future interactions you have with the University of Canterbury. If you do withdraw, we will remove all information relating to you, as long as you let us know by *1 July 2017.* After that date, we will not be able to remove your information because it will not be practical as data analysis would have already occurred.

What are the benefits of the study?

Your help will provide information which will assist New Zealand primary schools in ensuring that modern classrooms provide the best listening environments for students.

What are the risks of the study?

There are no direct risks for you well-being in this study. You will be answering questions about your current knowledge as a year one teacher.

Will my information stay private?

The results of the study may be published, but your identity will be kept private throughout the study. Information you give will be confidential, with no information that could identify you being used in any study reports. We will not share your information with anyone else. We will keep the data in a locked filing cabinet and in password-protected computer files. We will destroy the data five years after the study finishes.

How can I find out about the study findings?

Please tick the box on the consent form if you want us to send you the study results. Be sure to provide your email address if you want the study results.

B.1 Research information sheet (page 3 of 3)

Has this study been approved?

The study has been checked and approved by the University of Canterbury Human Ethics Committee. If you have a problem or complaint about this research, contact: The Chair, Human Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch (humanethics@canterbury.ac.nz (03) 364 2987 ext 45588).

What do I do next?

If you would like to participate in this study or learn more about the study, please contact me by email at mde85@uclive.ac.nz.

Please tick the appropriate box below to indicate whether you agree to be a part of this study.

I agree to be a part of this study ☐

I do not agree to be a part of this study ☐

Kind Regards,

Megan Dempster.

B.2 Email used for initial recruitment (page 1 of 2)

Dear ____,

My name is Megan Dempster and I am a student in my final year of studying towards a Master's degree in Audiology at the University of Canterbury.

Our final year requires us to write a thesis, and with the current shift in NZ towards modern learning environment classrooms, I decided to focus my research around how these affect classroom acoustics and what teachers can do within these environments to assist in supporting an acoustically sound learning environment with the resources they are supplied. In order to do this, I need the help of some year one teachers. I would be happy to come and meet with you should you have any questions regarding this process.

In September 2016, the Ministry of Education published a set of acoustic guidelines regarding the optimal way to design a quality learning space. This document provides guidance and technical requirements for the design of school buildings in NZ (as of January 1, 2017). The acoustic performance of learning areas has a direct impact on the usability of the space and learning outcomes. As such, the purpose of these guidelines is to assist in the successful design of modern learning environments. I am reviewing these guidelines as part of my research.

As part of this, I have created a survey which I would like to distribute around the year one teachers of your school so I can learn more about their understanding of acoustics in the classroom and which areas teachers think it is most important to improve in with regards to this. I have attached an information sheet regarding this and would really appreciate it if your staff would be interested in participating. Each participant will be given a $30 petrol voucher as acknowledgement of their time and contribution to the study.

If you would be willing to help with this study, please reply to me on this email address mde85@uclive.ac.nz and I will be in touch regarding distribution of the survey. Your assistance would be greatly appreciated.

B.2 Email used for initial recruitment (page 2 of 2)

Thank you for your time,

Kind Regards,

Megan.

APPENDIX C: *SURVEYS*

C.1 Pre-survey (page 1 of 5)

Pre-survey

1). Do you currently have a student in your class with hearing loss/have you ever taught a child with a hearing loss?

- Yes

- No

- Maybe

2). In your opinion, what aspects of your classroom are most important? Rank those categories below, with 1 being most important and 5 being least important.

- Lighting
- Ventilation
- Listening environment (acoustics)
- Equipment
- Room space

3). How do you rate your classroom listening environment?

- Very good
- Good
- Acceptable
- Poor
- Very poor

4). What factors might make it hard for students to hear well in your classroom?

- Open plan classroom style
- Too much echo in room
- Too much noise from outside room
- Noise level too high
- Other (specify)

5). Have you heard of the term 'reverberation'?

- Yes
- No
- If yes, what is your understanding of its meaning in terms of classroom acoustics?

C.1 Pre-survey (page 2 of 5)

6). During your pre-service training, were you taught anything about classroom acoustics and how listening environments affect learning?

- Yes

- No

- If yes, please specify anything you can recall.

7). Have you attended any professional development events that have involved information about classroom acoustics and how listening environments affect learning?

- Yes

- No

- If yes, please specify anything you can recall.

8). Do you have any problems with noise created inside the classroom? (including noise created by students themselves).

- Yes
- No
- If yes, please specify.

9). What proportion of noise inside the classroom is student generated?

- None
- Some
- Most
- All

10). Please identify all other sources of noise inside the classroom?

- Equipment
- Air conditioning
- Heaters
- Lights
- Fans
- Other (please specify)

C.1 Pre-survey (page 3 of 5)

11). Which of those in the list above do you find most intrusive?

- Equipment
- Air conditioning
- Heaters
- Lights
- Fans
- Other (please specify)

12). Do you have any issues with outside noise entering your classroom? (including noise from adjacent rooms)

- Yes
- No

13). Please identify the sources of outside noise

- Traffic noise
- Lawn mowing
- Noise from other classrooms
- Noise from sports fields
- Corridors
- Other (specify)

14). How important do you think it is to eliminate or reduce these noises for the students?

- Extremley important
- Very important
- Moderately important
- Slightly important
- Not at all important

15). What do you think could be done to eliminate these noises from outside your classroom?

- Please elaborate
- Unsure

16). Which source of noise is more bothersome in your classroom?

- Noise made inside the classroom
- Noise coming into the classroom from outside

C.1 Pre-survey (page 4 of 5)

17). Have you heard of the Acoustic Guidelines which were published by the Ministry of Education?

- Yes
- No
- If yes, please state what you can recall about these.

18). Approximately what percentage of the time do you spend in the classroom teaching in each of these styles?

- Mat work
- Group work
- Didactic/blackboard
- Other

19). Do you think acoustics in your classroom have a direct effect on the students learning ability?

- Yes
- No
- Don't know

20). If yes, please explain why you think the acoustics in your classroom have a direct effect on students learning ability.

21). From where in the classroom do students appear to be able to hear your instructions best?

- Easy everywhere
- Near the teacher
- Far from the teacher
- In the centre of the room
- Near the back
- At the sides
- Have not considered this

22). From where in the classroom do students appear to have the most difficulty hearing?

- Easy everywhere
- Near the teacher
- Far from the teacher
- In the centre of the room
- Near the back

C.1 Pre-survey (page 5 of 5)

- At the sides
- Have not considered this

23). Did the content of the information package alter the way you set up your classroom?

- Yes
- No
- Not yet, but it has made me think about it in the future.

24). Please note any further comments you would like to make on the subject of this questionnaire.

C.2 Post-survey (page 1 of 4)

Post-survey

1). Is the school you teach currently using modern learning environments?

- Yes
- No
- In the process of transitioning to modern learning environments at the moment.

2). In your opinion, what aspects of your classroom are most important? Rank those categories below, with 1 being most important and 5 being least important.

- Lighting
- Ventilation
- Listening environment (acoustics)
- Equipment
- Room space

3). How do you rate your classroom listening environment?

- Very good
- Good
- Acceptable
- Poor
- Very poor

4). What factors might make it hard for students to hear well in your classroom?

- Open plan classroom style
- Too much echo in room
- Too much noise from outside room
- Noise level too high
- Other (specify)

5). Have you heard of the term 'reverberation'?

- Yes
- No
- If yes, what is your understanding of its meaning in terms of classroom acoustics?

6). Do you have any problems with noise created inside the classroom? (including noise created by students themselves).

- Yes

C.2 Post-survey (page 2 of 4)

- No
- If yes, please specify.

7). What proportion of noise inside the classroom is student generated?

- None
- Some
- Most
- All

8). Please identify all other sources of noise inside the classroom?

- Equipment
- Air conditioning
- Heaters
- Lights
- Fans
- Other (please specify)

9). Which of those in the list above do you find most intrusive?

- Equipment
- Air conditioning
- Heaters
- Lights
- Fans
- Other (please specify)

10). Do you have any issues with outside noise entering your classroom? (including noise from adjacent rooms)

- Yes
- No

11). Please identify the sources of outside noise

- Traffic noise
- Lawn mowing
- Noise from other classrooms
- Noise from sports fields
- Corridors
- Other (specify)

C.2 Post-survey (page 3 of 4)

12). How important do you think it is to eliminate or reduce these noises for the students?

- Extremley important
- Very important
- Moderately important
- Slightly important
- Not at all important

13). What do you think could be done to eliminate these noises from outside your classroom?

- Please elaborate
- Unsure

14). Which source of noise is more bothersome in your classroom?

- Noise made inside the classroom
- Noise coming into the classroom from outside

15). Have you heard of the Acoustic Guidelines which were published by the Ministry of Education?

- Yes
- No
- If yes, please state what you can recall about these.

16). Approximately what percentage of the time do you spend in the classroom teaching in each of these styles?

- Mat work
- Group work
- Didactic/blackboard
- Other

17). Do you think acoustics in your classroom have a direct effect on the students learning ability?

- Yes
- No
- Don't know

18). If yes, please explain why you think the acoustics in your classroom have a direct effect on students learning ability.

C.2 Post-survey (page 4 of 4)

19). From where in the classroom do students appear to be able to hear your instructions best?

- Easy everywhere
- Near the teacher
- Far from the teacher
- In the centre of the room
- Near the back
- At the sides
- Have not considered this

20). From where in the classroom do students appear to have the most difficulty hearing?

- Easy everywhere
- Near the teacher
- Far from the teacher
- In the centre of the room
- Near the back
- At the sides
- Have not considered this

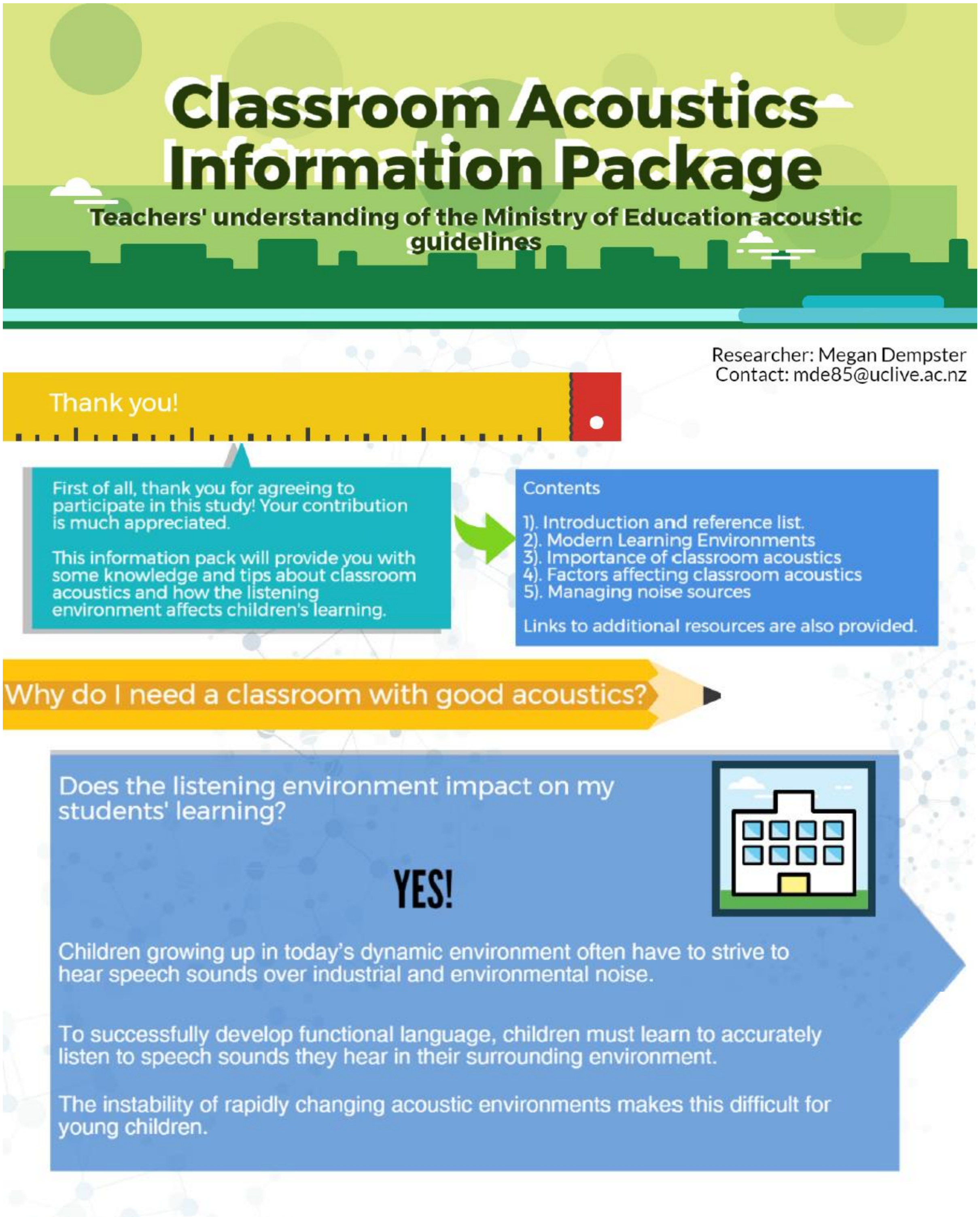
21). Did the content of the information package alter the way you set up your classroom?

- Yes
- No
- Not yet, but it has made me think about it in the future.

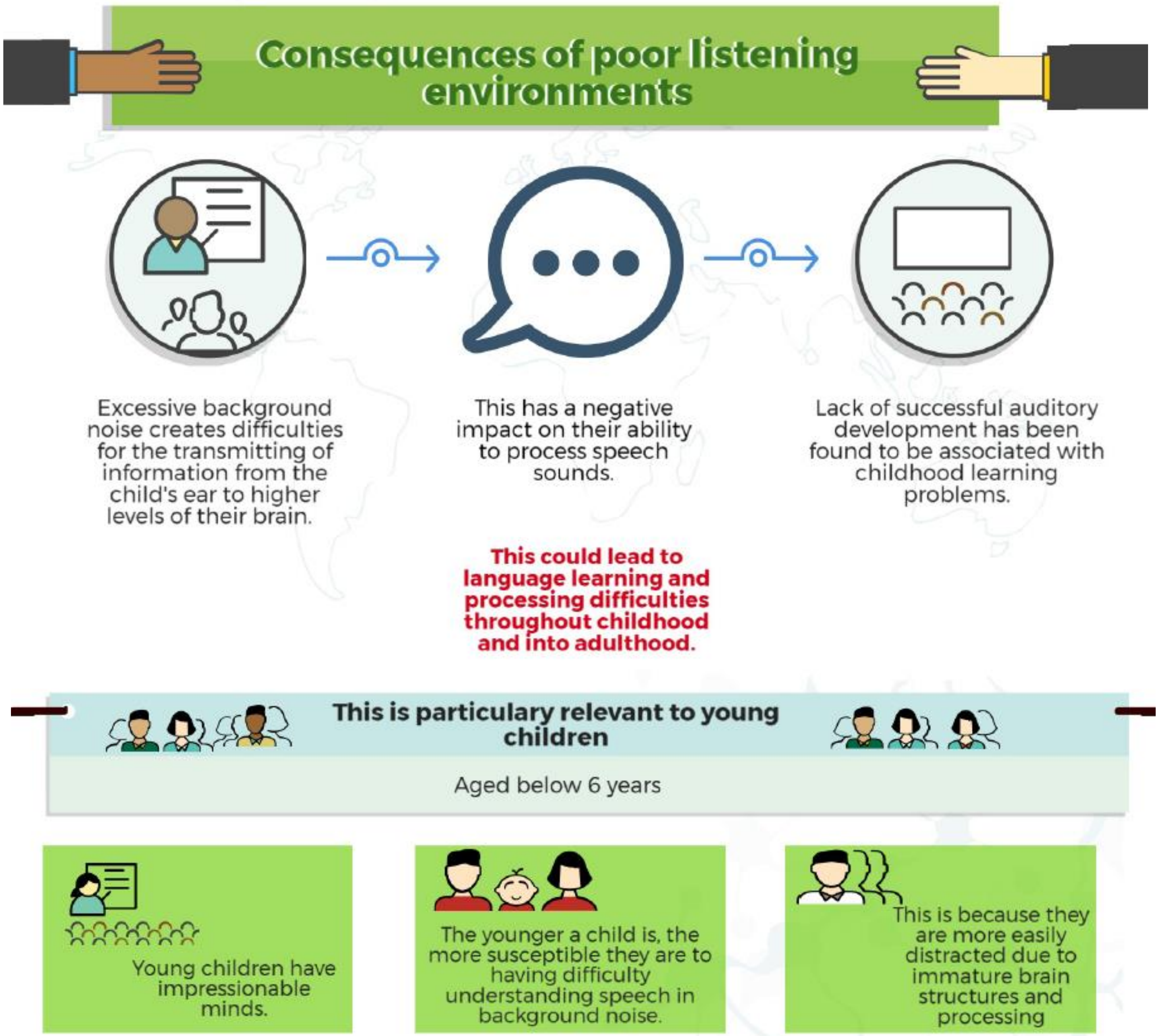
22). Please note any further comments you would like to make on the subject of this questionnaire.

APPENDIX D: *INFORMATION PACKAGE*

D.1 Information package (page 1 of 15)



D.1 Information package (page 2 of 15)



Additional Resources

As teachers, you are probably well aware that the classroom environment is very important.

The classroom is a place where you educate young minds and the layout of the classroom has a significant impact on how students learn.

This includes the size of the classroom, colour of materials, types of furniture, floor, wall and ceiling coverings, the amount of natural light and physical layout of spaces. While it is not always possible to have your own personal input on some of these factors, one thing that teachers can do to benefit their students is to learn about how the acoustic environment impacts on their students and what they can do to help their classroom environment be as good a learning environment as possible.

This information pack will help to shed some light on some of these areas. An informative website is http://classroom.4teachers.org/.

This provides a visual tool which provides an opportunity for experimentation with the layout of your classroom without any heavy lifting! This may help you to visualise where you could potentially make some changes to your classroom environment.

D.1 Information package (page 3 of 15)

Children are quick learners, however (on average) strong and independent reading skills are not usually present until approximately the fifth year of education (Matkin et al, 1996). Therefore, it is critical that children learn in an acoustically sound environment in order to have good understanding of the verbal instructions received by their teacher.

Modern Learning Environments (MLEs) are based on the idea that successful learning is a result of active engagement in the learning process through social interactions and active participation in the learning process.

Example of a modern learning environment.

Reference list

For further reading about any of the concepts that will be covered in the following pages, please read:

American National Standards Institute. (2002). Acoustical performance criteria, design requirements, and guidelines for schools (ANSI S12.60-2002). New York, NY: Author.

American Speech-Language-Hearing Association. (2005). Acoustics in educational settings. Available from www.asha.org/policy.

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Designing Quality Learning Spaces - Acoustics. (2016). Ministry of Education.

Matkin, N. (1996). The potential benefits of amplification for young children with normal hearing. In F. Bess, J. Gravel & A. Tharpe (Eds.), Amplification for children with auditory deficits. Nashville, TN: Bill Wilkerson Central Press

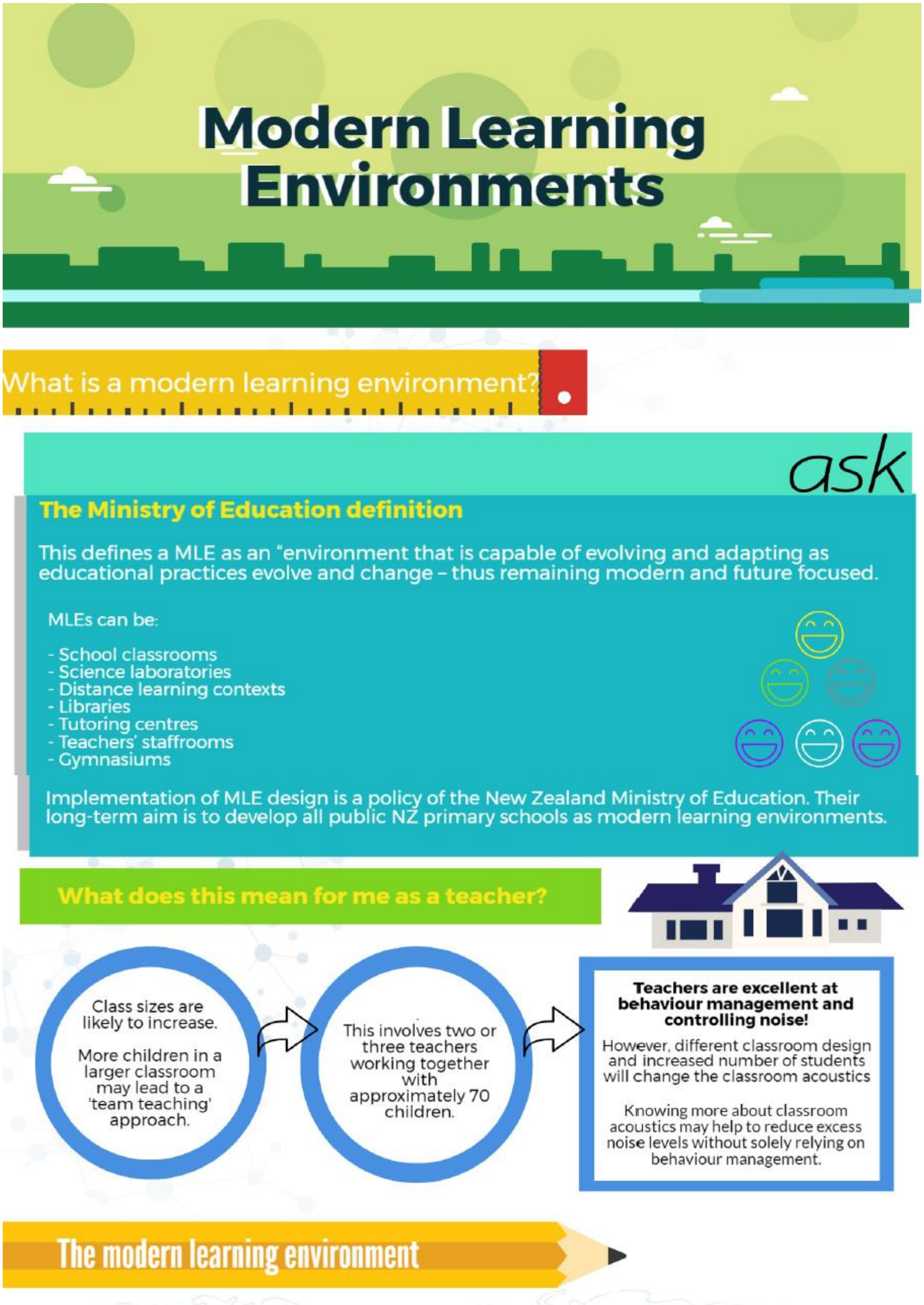
Picard, M & Bradley, J.S. (2001). Revisiting speech interference in Classrooms. Audiology, 40(5), 221.

Shield, B.M., & Dockrell, J.E. (2003). The effects of noise on children at school: A review. Building Acoustics, 10(2), 97-116.

Valentine, J., & Wilson, O. (2002). Classroom Acoustics: A New Zealand Perspective. The Oticon Foundation, 1-44. Retrieved March 28, 2017 from http://www.oticon.org.nz/pdf/classroomacousticsreportprintedversion.pdf

Please contact me if you would like copies of any of these publications

D.1 Information package (page 4 of 15)



D.1 Information package (page 5 of 15)

The changing classroom

This diagram shows an example of a modern learning environment.

The yellow space provides an indication of the entire classroom area.

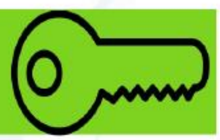
Within this space, several 'zones' exist which have been created for seperate activites.

Due to the design of MLEs having a lot of different activites taking place in one area, it can be difficult to manage noise.

This information pack will address some ways to tackle excess classroom noise

Features of modern learning environments

3 key features



FLEXIBILITY

A flexible classroom should have the ability to:

- Combine two classes into one for team teaching.
- Split a class into small groups
- Distribute these groups over a larger area
- Combine different classes who are studying complementary learning areas

OPENNESS

- Fewer walls
- More glass
- Have a central learning 'hub' which is the center point of class.
- This hub can be shared by different classes
- The hub should allow students and teachers alike to observe others and be observed by others.

D.1 Information package (page 6 of 15)

ACCESS TO RESOURCES

- The 'hub' described above should be surrounded by breakout spaces.

- These should be allocated for a variety of different activities like reading, group work, project space and presentation space.

- Surrounding areas often have a mix of wireless and wired technology which allows for fast, easy access to knowledge.

What does a Modern Learning Environment look like?

Changes to how we learn

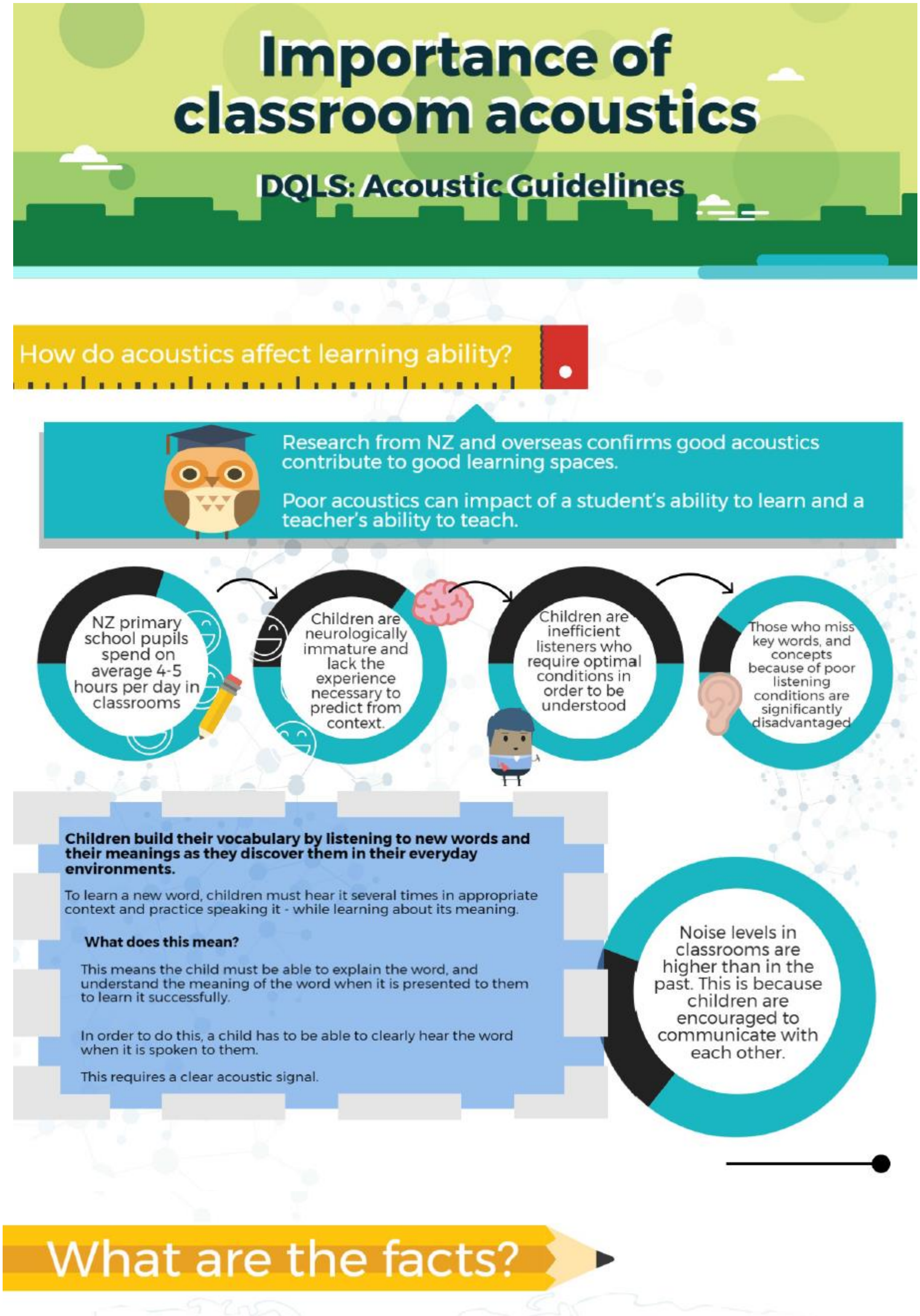
These are examples of flexible learning spaces which have break-out spaces.

The break-out spaces allow for co-teaching of learning groups.

They also allow for teacher/student and student/student learning opportunities.

Now we know a bit more about the aims of the MLE, we can talk about how this affects classroom acoustics and some tips for how to manage this.

D.1 Information package (page 7 of 15)



D.1 Information package (page 8 of 15)

Is there any proof?

Lots!
Studies have proven that excessive noise has a negative effect on children's speech perception, attention, reading, spelling, behaviour and overall academic achievement (Berg, Blair & Benson, 1996; ANSI, 2002; ASHA, 2005).

Children's performance on standardised tests of English is negatively correlated with the overall classroom noise level (Shield& Dockrell, 2003).

Working memory

Learning new words requires working memory.

The presence of background noise interferes with integrity of working memory.

Children have a limited working memory capacity compared to young adults.

What impact will this have?

This means that listening to speech is noise has a large impact on young children's ability to learn and remember new words.

Differences between traditional classrooms and modern classrooms

Traditional learning environments

Traditionally, education in NZ was implemented using one teacher for a large group of students.

The layout was typically a rectangular space with rows of desks and chairs for all students learning within that room.

The blackboard was situated behind the teacher's desk at the front of the classroom.

A method of direct instruction was used, where the educator stood at the front of the classroom and presented information directly to the students.

Whilst this teaching model communicates the essential points of knowledge, it has received criticism as it does not allow for independent thinking.

Consequently, students fail to learn how to successfully gather, analyse and synthesise information.

Modern learning environments

NZ primary schools should support the provision of creating, communicating and decision making.

The Ministry of Education has decided that this is best provided through implementation of MLEs in all public schools.

The design of the classroom itself is often centred around a 'home-base' for students where the majority of teaching and learning occurs. Surrounding this are 'break-out spaces' which provide access to a variety of diverse, multi-purpose learning environments.

Children are active participants in their learning. By questioning themselves and their learning strategies, children become actively engaged in their learning process

Promotion of open communication and active decision-making made it necessary to alter the design of the modern classroom to facilitate an open design which allowed for activities and discussions.

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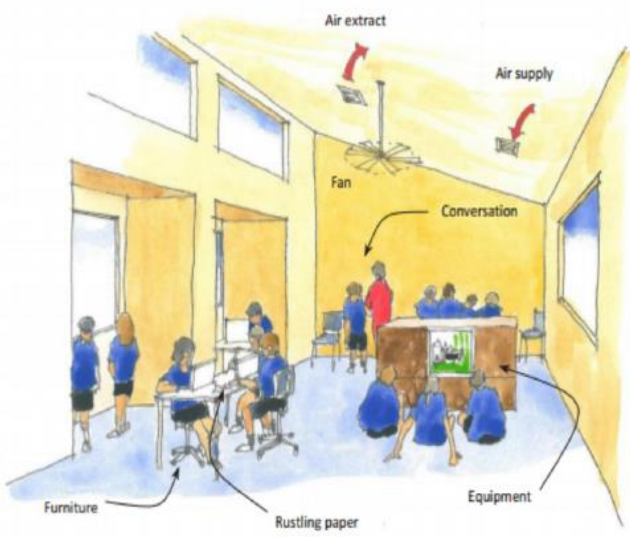
Which changes could be made to the classroom below to improve its acoustics?



Add rug or mat to floor

Drapes over windows which can be pulled if necessary

Movable partitions to assist with group work

Absorptive wall tiles

Absorptive ceiling tiles

Add wall hangings with soft textures (e.g., soft fabrics).

Use soft furnishings like bean bags or thick cushions

Place blankets on top of equipment if not in use

Soft materials should be placed opposite hard materials as much as possible to stop sound bouncing between surfaces.

Factors affecting room acoustics

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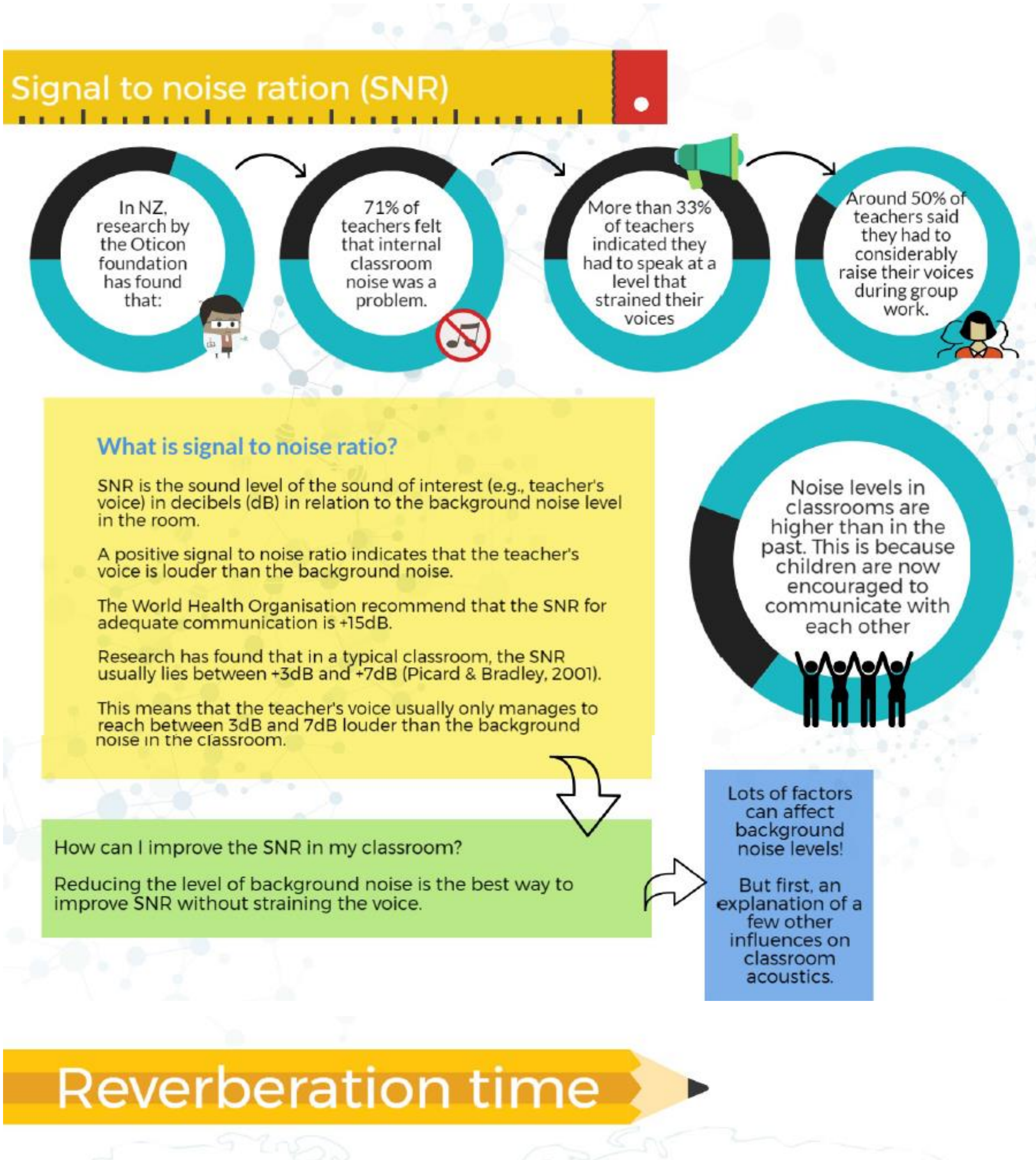

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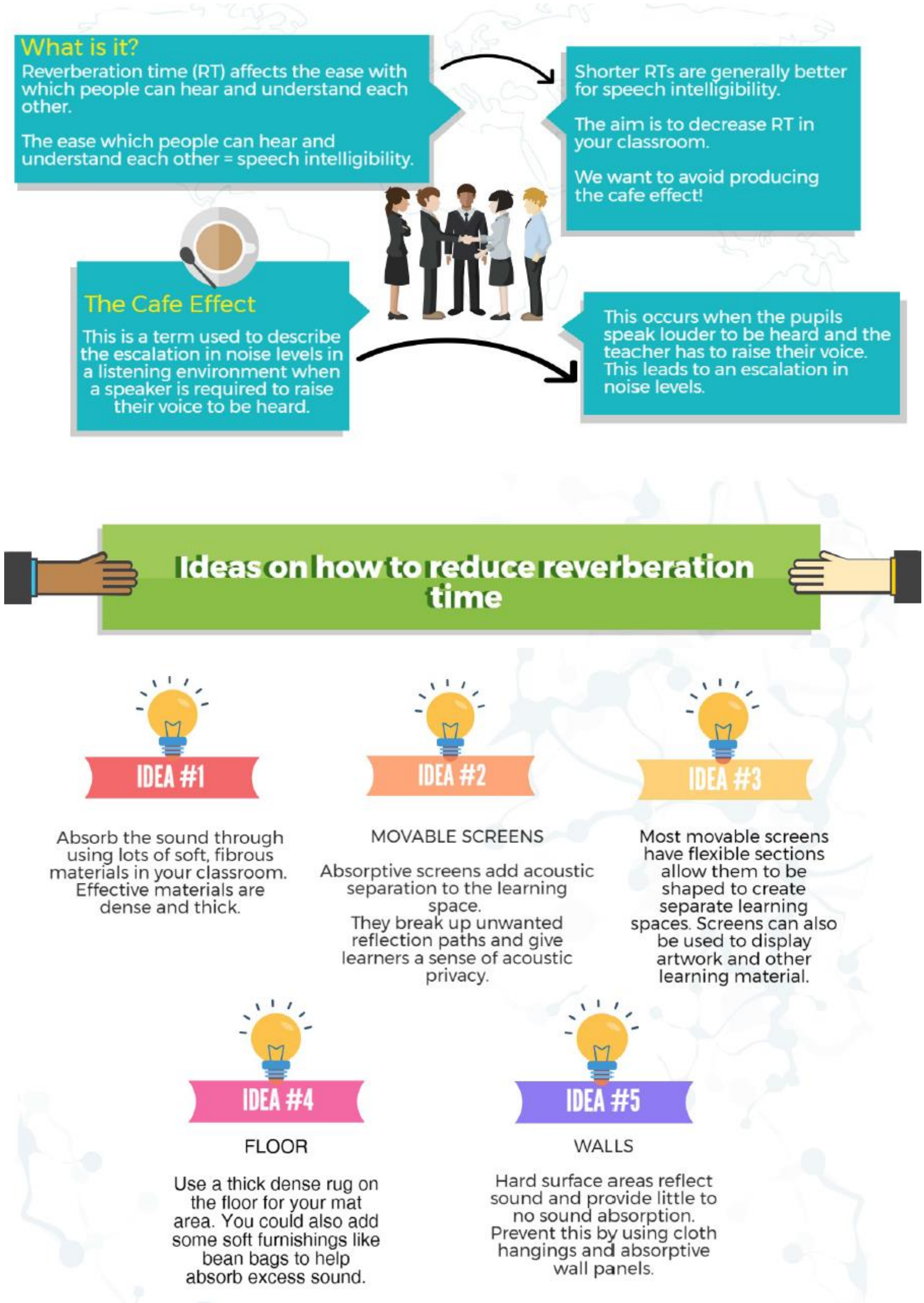

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What type of materials should I use to help reduce background noise?

Classrooms need a variety of treatment thicknesses to absorb both high and low frequency sounds.

High Frequency sounds affecting the classroom

- Children's voices
- Laughter
- School bells

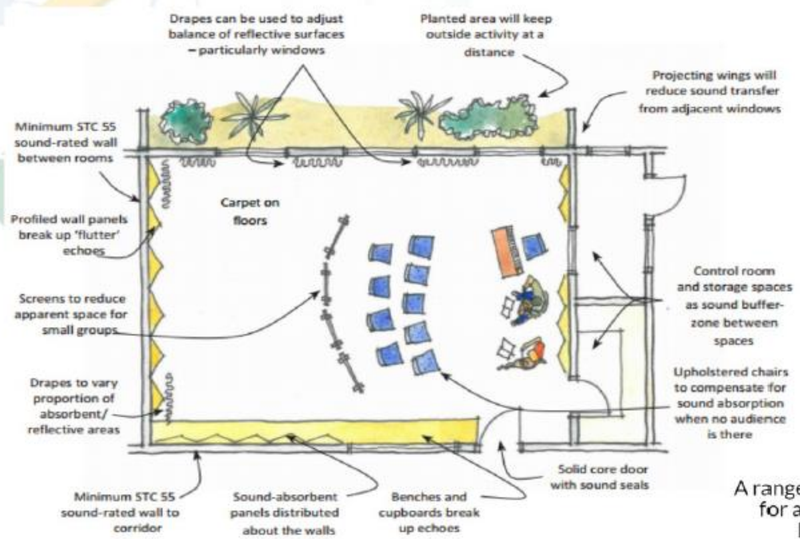
Low Frequency sounds affecting the classroom

- Ceiling fans
- Lawnmowers
- Traffic noise

Thin materials (less than 50 mm) have good absorption for high frequencies, but less absorption for low frequencies.

The opposite is also true. This means materials thicker than 50mm are better at absorbing low frequencies as opposed to high frequencies.

Thin Materials	Thick Materials
- Blankets	- Bean-bags
- Sheets	- Cushions
- Rugs	- Pillows
- Curtains	- Sound absorbent panels



A range of possible acoustic treatments for a classroom as specified by the DQLS acoustic guidelines.

Managing noise sources

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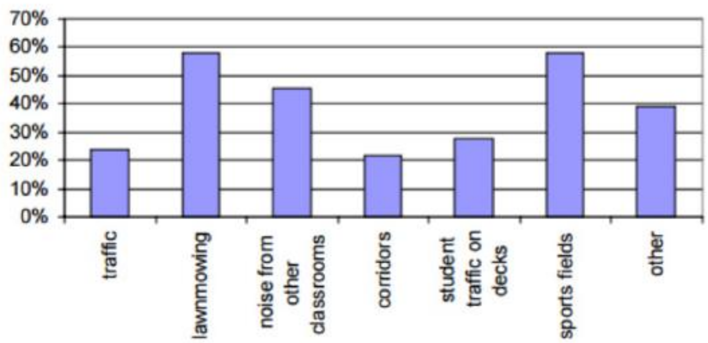
External noise sources

NZ primary schools generally do not use mechanical ventilation and air conditioning systems. Such systems are widely used in North American and European schools which means classrooms have high background noise levels even when unoccupied. As such, ventilation creates a problem in NZ classrooms during summer as a lot of windows are usually open, allowing for entry of external noise.

Sources of Intrusive External Noise

(% of concerned teachers identifying each noise source)



The Oticon Study (2002) identified the sources of external noise which teacher's found most difficult to deal with while teaching in the classroom.

These noise sources are identified in the graph to the left.

Managing external noise

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Short of keeping windows closed, external noise can be difficult to manage as the teacher often has no control over the events taking place outside their classroom.

Things you could try

Sitting children away from noise sources

Having as large a separation as possible between play areas and classrooms

Raise awareness of staff and school administration to the risk of outside noise entering the classroom (e.g., lawn mowing scheduled outside school hour)

HELP! Nothing is working

If problems are extreme

It may be helpful to speak to your Principal to investigate or liase with the Ministry of Education regarding:

Consulting the local road authority to help reduce the volume of traffic in the area or using quiet road surfaces to decrease traffic noise.

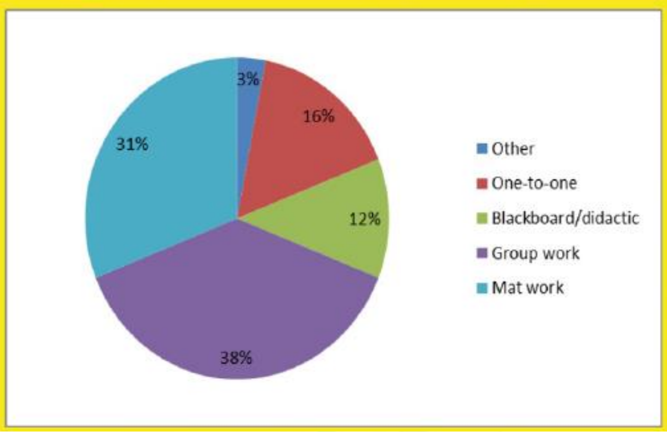
Planning and zoning the site to minimise noise.

Installing noise barriers,

Shielding spaces with other buildings that are less noise sensitive

Using thicker walls

Managing internal noise



The Oticon study concluded that in NZ primary schools 69% of teaching time was spent in mat work or group work and only 12% in didactic whiteboard teaching.

The graph to the left shows the proportion of time teachers spend teaching in each style

Classrooms are noisy places.

59% of teachers reported that most or all of the noise created inside the classroom is student generated.

Internal sources of noise:

Computers

Fluorescent lighting

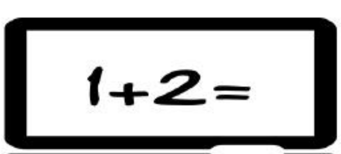
Heating

Noise generated by the students and teachers

Controlling internal noise

Noise levels in classrooms are undoubtedly higher than in the past because children are encouraged to communicate with each other.

Reducing reverberation times will assist in reducing internal noise levels.



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Helping control internal noise levels

Movable screens

To be effective, screens should be a suitable height and positioned to reduce direct sound paths. Screens should be stable and appropriately designed to ensure they remain upright.

Absorptive panels

The use of movable furniture to define spaces and zones, provide nooks and quiet corners and provide acoustic separation that is easily reconfigurable is recommended.

The use of absorptive panels around walls is also helpful.

Hearing Assistive Technologies

Soundfield systems or FM systems can help students to listen in busy classroom environments.

A soundfield system acts in a similar way to the use of a public address (PA) system; speakers in the classroom project speech from the teacher, who has a clip on microphone.

This means that there is an improved signal to noise ratio for everyone listening. Basically, it becomes easier to hear the person who is talking over all of the background noise. It may benefit teachers as they will have reduced vocal strain and less need to repeat instructions.

This can be a great option to help assist listening. However, this would require permission from the school for installation of speakers in the appropriate areas.

Personal FM systems act as though the speaker's mouth is right next to the ear of the listener. It works by the teacher wearing a clip on microphone which sends signals directly to a receiver on the student's ear (usually in the form of a hearing aid).

The purpose of this is to improve the signal-to-noise ratio and make it much easier for the student to hear over background noise. This does not benefit groups however. The use of this type of technology is designed for individuals who have particular difficulty hearing in background noise.